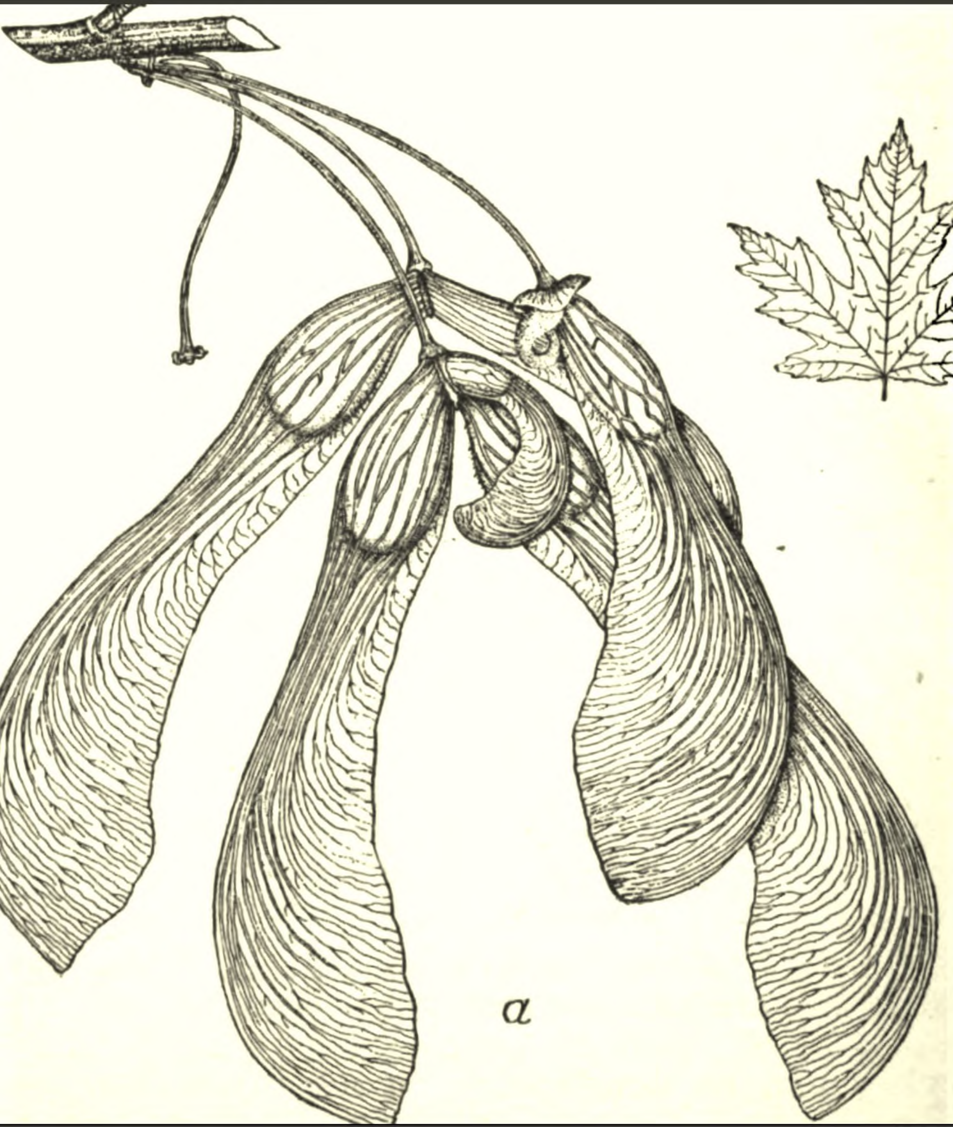
This is a reproduction of a library book that was digitized by Google as part of an ongoing effort to preserve the information in books and make it universally accessible.

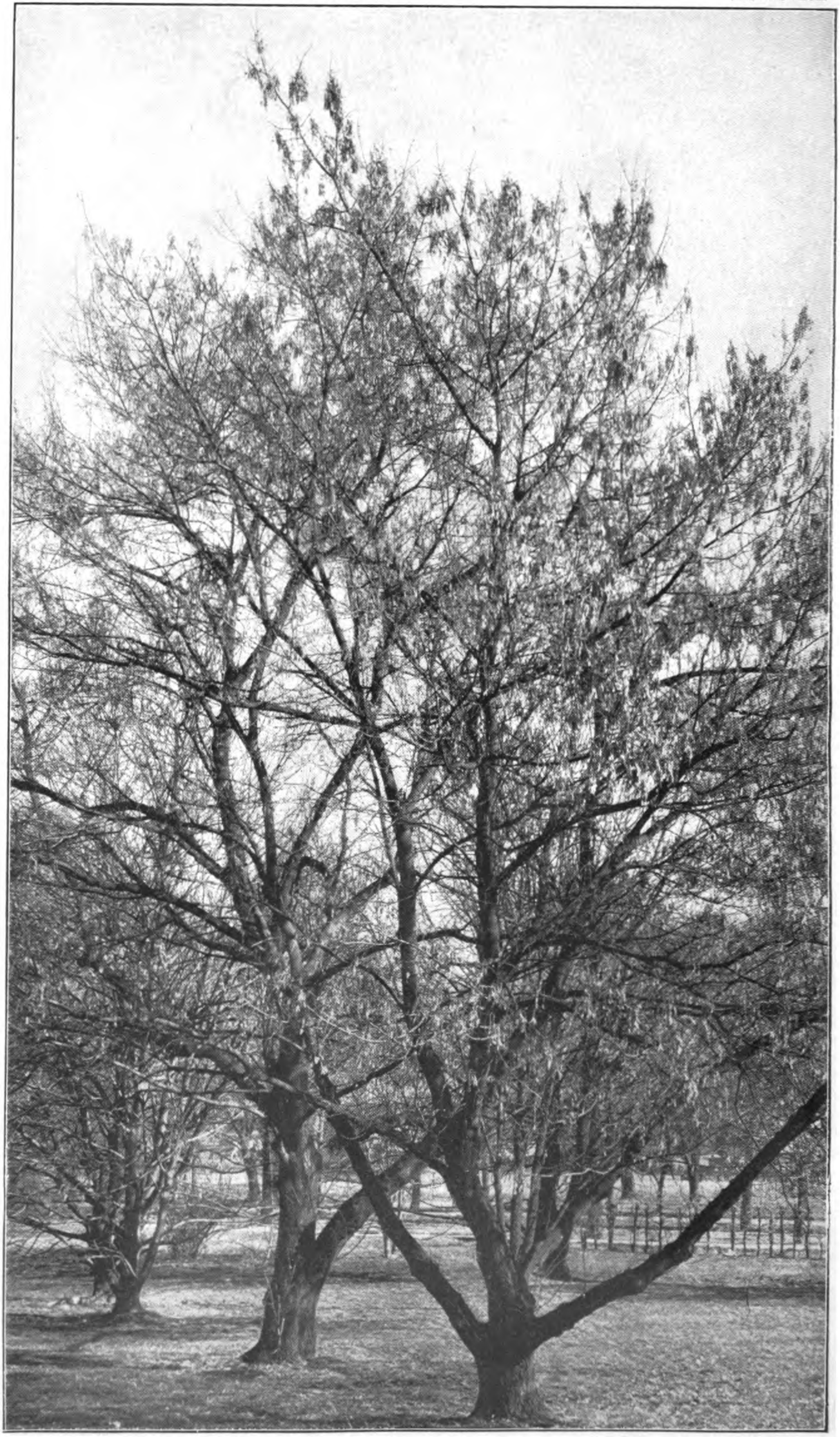
Google™ books

http://books.google.com



The forest nursery

George Bishop Sudworth



BOXELDER IN DECEMBER, WITH FULL CROP OF SEED STILL ON THE TREE, SHOWING OPPORTUNITY FOR LATE COLLECTING. MARYLAND.

BULLETIN No. 29.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF FORESTRY.
GIFFORD PINCHOT, Forester.

THE FOREST NURSERY:

COLLECTION OF TREE SEEDS AND PROPAGATION OF SEEDLINGS.

BY

GEO. B. SUDWORTH,
DENDROLOGIST, DIVISION OF FORESTRY.

1862 1889

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1900.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF FORESTRY,
Washington, D. C., August 1, 1900.

SIR: I have the honor to transmit herewith a paper entitled "The Forest Nursery: Collection of Tree Seeds and Propagation of Seedlings," prepared by Mr. Geo. B. Sudworth, Dendrologist of the Division of Forestry, and to recommend its publication as Bulletin No. 29 of this Division. Mr. Sudworth has brought together, in concise and original form, information of peculiar value to tree planters. His paper will be especially useful in the tree-planting work of this Division and to all farmers interested in raising trees.

Respectfully,

GIFFORD PINCHOT,
Forester.

Hon. JAMES WILSON,
Secretary.

PREFACE.

The purpose of this bulletin is to inform farmers and others interested in tree planting how to secure forest-tree seeds and to raise seedlings at a small cost. The professional nurseryman will find here little with which he is not already familiar. Correspondence received during the last twelve years by the Department of Agriculture from farmers and other land owners asking advice on how to procure tree seeds and how to raise seedlings shows an extensive demand for such information. Many treatises have been written on the propagation of forest trees, but most of these books lack the simpler and special instructions which the Department's correspondence shows to be in greatest demand, especially among farmers. Moreover, a great many of the books published are now out of print, or, for the most part, entirely unknown to the large class of tree planters in need of advice.

In endeavoring to give this information one point has been kept prominently in view—to lead the propagator to produce plant material which will succeed best under inexperienced management. The number of plants to be grown on the allotted space of seed bed and nursery has, therefore, been sacrificed to what is believed to be a more important consideration—the production of vigorous plants.

The treatment of the various subjects considered is based upon a long experience in collecting and storing large quantities of tree seeds and in their propagation, upon a careful study of the practices of professional nurserymen, and upon an extensive study of tree seedlings in the wild state.

Mention is made in this bulletin of the desirability of cooperation among the farmers of a locality in order that each may secure a larger assortment of seeds than would otherwise be possible. Naturally, all opportunities for private cooperation will be improved wherever feasible. In some cases, however, this cooperation will be difficult or impossible for various reasons, and the sources at hand from which to secure tree seeds may also be small. For these reasons it seems very desirable that a system of State cooperation, affording large privileges of seed exchange, be established under the direction of State experiment stations. All planters could thus be aided, and especially those with meager supplies of seed.

Under this plan, the duty of each station should be to receive the surplus seeds of various collectors in the State interested in exchange. The combined surplus would represent the exchange stock for the State, and could be so apportioned to applicants by the station that each contributing collector would receive supplies of seed not available in his locality.

G. B. S.

CONTENTS.

Page.

INTRODUCTION 9

COLLECTING TREE SEEDS AND CARE BEFORE PLANTING 11

- Economy of collecting tree seeds 11
- Regions of seed supply 11
- Seed collectors and cost of seeds 11
    - List of market prices for tree seeds 12
- Seeds desirable to collect 13
- When to collect seeds 18
- Where to collect seeds 22
- How to collect seeds 23
- Preliminary treatment and care of fruits and seeds 24
- Storing seeds 30
    - General remarks 30
    - Early maturing seeds 30
    - Late maturing seeds 30
        - General consideration 31
        - Preliminary storage 31
        - Permanent storage 31
- Testing the vitality of seeds 33
    - Provisional test 33
    - Absolute or germinating tests 34
        - Sand, soil, and sphagnum moss tests 34
        - Other tests 34
- Identity of tree seeds 34
- Vitality of tree seeds 35
- High and low germination of seeds 36
    - Percentage of germination 36
- Prompt and slow germination 37

PROPAGATION OF TREES FROM SEEDS AND CUTTINGS 38

- Propagating from seeds 38
- Natural seeding 38
- Planting and sowing seed with field crops or on prepared and unprepared ground 39
- Seed-bed culture 40
- Location, soil, preparation, and size of the seed bed 40
    - Location of seed bed 40
    - Soil and preparation 41
    - Size of the seed bed 41
- Box culture 41
- Sowing the seed 42
    - Comparison of broadcast and drill sowing 42

PROPAGATION OF TREES FROM SEEDS AND CUTTINGS—Continued. Page.
Sowing in drills or rows ... 42
Thick and thin sowing ... 43
Spacing seeds in the row ... 43
Table showing the number of tree seeds per ounce and pound, and also the approximate number of linear feet of seed drill covered by each quantity ... 44
Marking seed rows ... 44
When to sow ... 44
Covering seeds in the seed bed ... 45
Moisture in seed beds ... 45
Shading seedlings ... 46
General remarks ... 46
Making screens ... 46
How long seedlings should be shaded ... 47
Watering seedlings ... 48
Cultivation of seedlings in the seed bed ... 48
Table of approximate height of 1-year-old seedlings ... 49
"Damping off" ... 49
Propagating trees from cuttings ... 50
Making cuttings ... 50
Setting cuttings ... 50
WINTERING AND TRANSPLANTING SEEDLINGS ... 51
Wintering seed-bed stock ... 51
Transplanting seed-bed stock to the nursery ... 52
General considerations ... 52
Root pruning ... 53
Fall and spring transplanting ... 53
Fall transplanting ... 54
Taking up seedlings ... 54
Transporting stock from seed bed to nursery ... 54
Spring transplanting ... 55
Care of nursery stock ... 56
Cultivation ... 56
Watering ... 57
Wintering ... 57
How long stock should remain in the nursery ... 57
USE OF WILD SEEDLINGS ... 58
Supply of wild seedlings ... 58
Time for collecting wild seedlings ... 58
Heeling in ... 59
LIST OF USEFUL TIMBER TREES TO PLANT ... 59
Geographical range of species, character of the seed, time to collect, and proper storage for seed of each species ... 60

ILLUSTRATIONS.

PLATES.

Page.

Boxelder in December, with full crop of seed still on the tree, showing opportunity for late collecting. Maryland .... Frontispiece.

PLATE I.—Fig. 1, Honey Locust seed pods thrown by wind, showing opportunity for securing seeds easily in mild climate, December, Maryland; Fig. 2, Chestnut Oak acorns after an early spring forest fire has burned off the protecting cover of leaves, showing the germination last fall of several acorns under this protection, Maryland 18

PLATE II.—Variation in size and form of seeds: *a*, White Ash seed; *b*, Oregon Ash seed; *c*, Red Ash seed; *d*, Green Ash seed. (Natural size.) 34

PLATE III.—Common variation in size and form of seeds: *a*, Blue Ash seed; *b*, Black Ash seed; *c*, Water Ash seed. (Natural size.) 34

PLATE IV.—Rocky Mountain Juniper seedlings, 2 years old, 8 to 18 inches high. One-eighth of an acre of seed bed, containing 1,000,000 plants and showing an exceptionally dense stand from broadcast sowing 42

PLATE V.—Seedlings: *a*, Silver Maple seedling, 2 years old, 36 inches high, in permanent plantation, Nebraska; *b*, Boxelder seedling, 2 years old, 36 inches high, in permanent plantation, Colorado; *c*, Aspen seedling, 2 years old, 35 inches high, in permanent plantation, Utah 52

FIGURES.

FIG. 1.—White Pine: *a*, Closed mature cone; *b*, leaf bundle; *c*, seed. (Natural size.) 14

FIG. 2.—White Pine: *a*, *b*, *c*, *d*, Development of seedling from germination to the second year 15

FIG. 3.—Pitch Pine: *a*, Closed and, *b*, open mature cones; *c*, lower side of detached cone scale and seeds; *d*, leaf bundle. (Natural size.) 16

FIG. 4.—Shortleaf Pine: *a*, Open and, *b*, closed mature cones; *c*, upper and lower sides of detached cone scale with seed; *d*, leaf bundles, showing variation in the number of leaves; *e*, development of seedling from germination to first year. (Natural size.) 17

FIG. 5.—Red Pine: *a*, Open mature cone; *b*, leaf bundle; *c*, upper and lower sides of detached cone scales with seeds. (Natural size.) 19

FIG. 6.—Cones and seeds: *a*, White Spruce, closed and open mature cones, and upper and lower sides of detached scale and seed (seedling 10 days old); *b*, Bald Cypress, mature cone, section of same, and detached seed; *c*, open mature cone of Tamarack. (Natural size.) 20

Page.
Fig. 7.—Hemlock: *a*, Branchlet with open and closed mature cones; *b*, upper and lower sides of detached cone scale and seed; *e*, *d*, *c*, development of seedling from germination to first year. (Natural size.) 21
Fig. 8.—Red Juniper ("Red Cedar"): *a*, Branchlets with mature berries; *b*, mature seeds; *c*, development of seedling from germination to first and second years. (Natural size.) 23
Fig. 9.—Seeds and leaves: *a*, Sugar Maple, mature seed (natural size), mature leaf (¼ natural size); *b*, Red Maple, mature seed (natural size), mature leaf (½ natural size) 25
Fig. 10.—Seeds and leaves: *a*, Silver Maple, mature seed (natural size), mature leaf (¼ natural size); *b*, Boxelder, mature seed (natural size), mature leaf (¼ natural size) 26
Fig. 11.—Acorns, leaf, seed, etc.: *a*, White Oak, mature acorn (natural size), mature leaf (⅓ natural size); *b*, Black Oak, mature acorns (natural size); *c*, seed of common Catalpa (natural size); *d*, Honey Locust, extremities of mature pod and detached seed. (Natural size.) 27

THE FOREST NURSERY.

INTRODUCTION.

The art of raising forest-tree seedlings and planting trees is but little known among farmers, for whom it has very great economic interest.

For the farmer of the Eastern wooded country, the study of how to grow trees has not yet reached, nor is it likely to reach, the same degree of importance as for the Western farmer. The Eastern farmer has often to consider only what trees shall be allowed to grow up and what shall be introduced, while the Western farmer has to consider what may be grown and how. The greater interest centers about the Western planter because of his greater need for wood material, and also because the growth of trees under his conditions is most difficult.

The importance of establishing wood lots or shelter belts on farms that lack them is no less obvious than the necessity of raising the staple crops. The provident farmer can not afford to buy firewood, fence posts, or building timber any more than he can afford to buy corn and wheat. A part, if not all, of the wood material used on the farm can and should be grown there. The profit on this timber growth rightly belongs to the farmer, and it is therefore one which economic agriculture can not neglect.

The relative value of wood lots in the prairie region and the wooded East is, of course, different. To the prairie farmer the possession of a wood lot affording posts, rails, poles, and firewood is of very great importance, since, being in a treeless region and distant from the sources of wood supply, he would otherwise be compelled to pay high prices for such material. The Eastern farmer is less dependent, even though his wood lot has been cut off, for he lives in a wooded country, where posts, fuel, and lumber are comparatively cheap.

The scope of the farmer's tree planting will necessarily be small. In order to be entirely successful, smaller tree-planting operations should give useful results within one man's lifetime. To accomplish this the farmer tree planter must confine his attention chiefly to quick growing trees.

The efforts under the Timber Culture Act to establish forest growth in the plains region of the West can hardly be said to have been successful beginnings in forest planting; they were, however, attempts to meet the great necessity for timber in that region. Their failure has not demonstrated that trees can not be grown there, but rather that there is need of a better system and a more intimate knowledge of the special requirements of trees under trying conditions. For, however little evidence there is now that forests once existed to any extent on the Western plains, it is believed that trees can be made to grow in this region.

If forests ever existed in this nearly treeless region, with their disappearance has gone every chance of their unaided return. Here wild prairie land, or land left long uncultivated, rarely gathers upon its wind-swept surface the little islands and groves of trees so common in the East under precisely the same conditions of clearing. The trees that do exist are found only along the streams. The clearest inference from this fact is that the land, except adjacent to streams, lacks the soil moisture necessary to the natural reproduction of trees. In the East frequent rains and a humid climate give this moisture to the poorest soil. As a result, abandoned cleared fields quickly return to forest whenever the absence of heavy grazing and fire allows it. On the other hand, the deep, rich soils of the Western plains are reduced to semiaridity by the combined effects of scanty rainfall and hot drying winds. Even if tree seeds germinate under these unfavorable conditions, the tender seedlings speedily wither and die.

Some forest trees are at home in widely different soils and climates. Other trees can exist in certain kinds of soil only or in certain climates or surroundings. If not dependent upon these conditions for their whole life, they are so for the early part of it. The absence of one of these factors, as for example, an evenly moist soil, or protection against hot drying wind during the early critical period of a tree's life, means the failure of the species to extend unaided over areas where otherwise it might become established. The thousands of bushels of black walnuts planted in the plains region of the West did not fail to germinate; but many of them failed to produce trees, for the very good reason that the seedlings lacked a continued supply of soil moisture. The thin foliage could not produce enough shade to prevent the rapid evaporation of melted snows and spring rains. Without shade to conserve these waters to the soil, and with few or no summer rains and no irrigation, it was natural that so many walnut plantations should have failed in the drier plains regions.

In attempting now to establish forest trees in such dry treeless regions, the chief problem is to overcome these unfavorable conditions. This can be accomplished best by first starting the young seedling in the seed bed and growing it in the nursery until it is strong enough to maintain itself in the forest plantation. If the special needs of seedlings and young trees pointed out in this bulletin are supplied, the Western farmer may as successfully grow trees from the seed to maturity as he can farm crops. The eastern farmer has still better chances of success.

COLLECTING TREE SEEDS AND CARE BEFORE PLANTING.

ECONOMY OF COLLECTING TREE SEEDS.

Home collecting of seeds makes forest planting possible for the farmer, while the necessity of purchasing seed may place it beyond him.

The farmer or other land owner who contemplates planting forest trees must provide his stock either by raising it or buying it. To the average farmer the cost of this planting material, however small, is likely to be an important consideration. It is, therefore, always desirable and often indispensable that the farmer, by collecting seeds and raising seedlings himself, should reduce the cost of forest planting as much as possible. Most farmers can, without inconvenience or extra expense, give the attention and labor necessary for planting and cultivation.

REGIONS OF SEED SUPPLY.

Broadleaf trees are most abundant in the East, with some desirable conifers; only a few broadleaf kinds are found in the plains region, and conifers are abundant in the mountain regions of the West. Cooperation of farmers is important for a general supply.

It will often be difficult to find in one locality all the desirable kinds of trees from which to collect seed. The prairie regions will afford a limited number of broadleaf[1] tree seeds; the Western mountain regions, an abundance of coniferous seeds with a few broadleaf kinds; while the Eastern States will supply the largest number of broadleaf, together with some of the most desirable coniferous seeds.

Even in regions of abundant supply some localities will be poor in certain seed trees which a neighboring locality may contain in abundance. Under such circumstances cooperation between planters should lead to exchanges or other arrangements through which the lacking material may be obtained.

SEED COLLECTORS AND COST OF SEEDS.

Seed collecting is carried on mostly by nurserymen and professional collectors. The cost of seed is high because of the smallness and irregularity of the demand, the uncertainty of the crop, and the difficulty of collecting and keeping in growing condition.

Few persons are familiar with collecting tree seeds because it is confined chiefly to nurserymen and professional collectors. The price of tree seeds is usually very high, as compared with that of most field and garden seeds, partly because the demand for tree seeds is small and very irregular. Moreover, unlike field and garden seeds, a full and regular crop of tree seeds can not be found in all localities every season; since the habit of many kinds of trees is to bear seed only at intervals of from two to four years, or, on account of special accidents (frost, fire, etc.), at even longer intervals. In addition, the process of gathering tree seeds is for the most part more laborious than that of any other class of seeds. Trees must be climbed and the seeds picked off by hand, or the branches must be severely shaken or beaten to dislodge it. The wasteful practice of lopping off branches or cutting down trees solely to get the seeds should not be resorted to. The seeds of only a few trees, like the hickories, beech, walnuts, butternut, chestnut, oaks, etc., can be easily gathered after severe frosts and winds have made them fall.

---

[1] The term "broadleaf" is used here to designate all trees not conifers (Pines, Spruces, Firs, Larches, Hemlocks, etc.), being preferred to "deciduous" and "hardwood." "Deciduous" is incorrect for designating nonconiferous trees for the reason that many of these trees are evergreen. The term would also include some strictly deciduous-leaf conifers. The term "hardwood" is misleading, because it is often made to include woods both hard and soft, while in lumber markets it is used in contradistinction to the term "softwood," which is applied both to conifers and to some broadleaf trees.

The market price of tree seeds is enhanced also by the special care and devices necessary to preserve them in good condition until wanted for fall or spring planting. Only a few seeds can be planted immediately after they are gathered.

LIST OF MARKET PRICES FOR TREE SEEDS.

The following list shows the present range of market prices for tree seeds, to which must be added the cost of transportation:

Market prices for tree seeds.

Name of species.	Cost of seed per pound.	Name of species.	Cost of seed per pound.
Black Spruce	$3.75–$4.00	Bitternut Hickory	$0.15–$0.25
White Spruce	3.75– 4.00	Beech	.50– .75
Engleman Spruce	3.00– 8.00	Black Walnut	.10– .15
Blue Spruce	2.00– 6.00	Butternut	.10– .20
Sitka Spruce	3.50– 4.00	White Ash	.30– .60
Douglas Spruce	2.50– 4.50	Green Ash	.50– .75
White Fir	1.50– 5.00	Blue Ash	1.00– 1.50
Alpine Fir	2.50– 5.00	Oregon Ash	1.50– 2.00
Balsam Fir	1.25– 3.00	Black Ash	.75– 2.00
Noble Fir	3.00– 5.00	Red Ash	.75– 1.50
White Pine	1.50– 3.00	Sugar Maple	.75– 1.00
Sugar Pine	2.00– 2.50	Broadleaf Maple	.75– 1.00
Silver Pine	3.50– 4.00	Red Maple	1.25– 1.75
Limber Pine	4.00– 5.00	Silverleaf Maple	1.00– 1.50
Pitch Pine	2.50– 3.00	Box Elder	.35– .50
Bull Pine	2.00– 3.50	White Birch	1.50– 2.00
Longleaf Pine	3.00– 5.00	Sweet Birch	1.50– 2.00
Jack Pine	7.00–12.00	Yellow Birch	1.00– 2.00
Lodgepole Pine	7.50– 8.00	American Elm	1.00– 1.50
Lawson Cypress	3.75– 4.00	Cork Elm	1.50– 2.75
Red Cedar	.50– .75	Catalpa	.50– 1.25
Arborvitæ	2.00– 2.25	Black Locust	.50– .75
Giant Arborvitæ	3.00– 4.50	Honey Locust	.40– .60
Incense Cedar	3.00– 4.00	Black Gum	1.00– 1.25
Larch	12.00–16.00	Sweet Gum	2.50– 3.00
Big-tree	4.00– 6.00	Tulip-tree	.40– .50
Redwood	3.00– 5.00	Cucumber-tree	1.00– 1.50
Bald Cypress	.75– 1.00	Evergreen Magnolia	1.25– 1.50
White Oak	.10– .25	Osage Orange	.25– .30
Burr Oak	.20– .25	Black Cherry	.40– .60
Overcup Oak	.25– .30	Ailanthus	.25– .50
Spanish Oak	.30– .40	Persimmon	.75– 1.00
Red Oak	.20– .25	Holly	.75– 1.25
Black Oak	.15– .25	Basswood	1.00– 1.25
Shellbark Hickory	.15– .25	Sycamore	.50– .75
Pignut Hickory	.15– .20	Hackberry	.75– 1.00

SEEDS DESIRABLE TO COLLECT.

Secure seeds of as many of the useful timber trees of the home locality as possible. If these are slow-maturing trees, an assortment of fast-growing trees should be added; or, if the home trees are all quick-maturing trees, these may be supplemented by a few slower-growing kinds. Trees at home in a warm climate should not be planted in a cold climate. Trees from the northmost localities in the range of a species are more desirable than those from southern parts of the range. Seeds are best propagated in soils similar to those in which the parent trees grew.

The kinds of seeds desirable to collect will be determined largely by the purpose of the planting and by the kinds of trees adapted to the climate and soil at hand. For wooded regions the seed should be collected from as many of the timber species as are available. These may be represented now only by scattered individuals in the fence corners or elsewhere. They should not be overlooked. They are adapted to the region, and require no experiments to determine their fitness. Among such trees will be found Oaks, Walnuts, Hickories, Ashes, Elms, Sycamores, Beech, Maples, Cherry, Tulip-tree, Pines, Firs, Spruces, Hemlocks, and Larches. Most of them require at least seventy-five to one hundred years or more to reach maturity; but much useful timber will be produced by them in thirty to fifty years. To these must be added some faster-growing kinds, such as will give useful timber in ten to thirty years. Among these are Red Oak, Chestnut, Red and Silver Maple, Boxelder, Hardy and Common Catalpa, Black and Honey Locust, Cottonwood, Aspen, Largetooth Aspen, and Black Willow.

For the treeless regions, the small number of species available for the planter (Cottonwoods, Willows, Boxelder, Green Ash, Elms, etc.) may be supplemented by seeds from the timbered States. The choice of these must be based upon some knowledge of the soil and climate required by each species. All trees can not be successfully grown in any soil or climate. For example, the Bald Cypress of Southern swamps, or any other strictly Southern tree, will not endure the cold of a Minnesota winter. There are, however, many valuable timber trees that grow naturally from Canada to the Gulf States; and several extend even from the Atlantic to the Pacific coast. Among desirable trees, native in the Rocky Mountains, the Yellow Pine, Red or Douglas Fir, Rocky Mountain Juniper, and White Fir have already been successfully grown in the plains region far outside their natural range. Of Eastern trees, the White, Red, and Jack Pines, White Spruce, Red Cedar, White Birch, Sycamore, Black Cherry, and Black Walnut have been established in the same region. A few trees from this list, taken with the available local trees, will give the prairie planter an assortment large enough for all practical purposes. The planter is recommended to confine his operations to a small number of useful kinds, and preferably to those which grow naturally about his home.

Of seed grown outside the home locality, that from the most northern locality in the range of the species is preferable, because it will produce hardier plants than seed from more southern stations. Seeds should be taken from trees which are growing in soil as similar as possible to that in which the new stock is to grow. Individual trees of some species of forest trees are found growing naturally in both

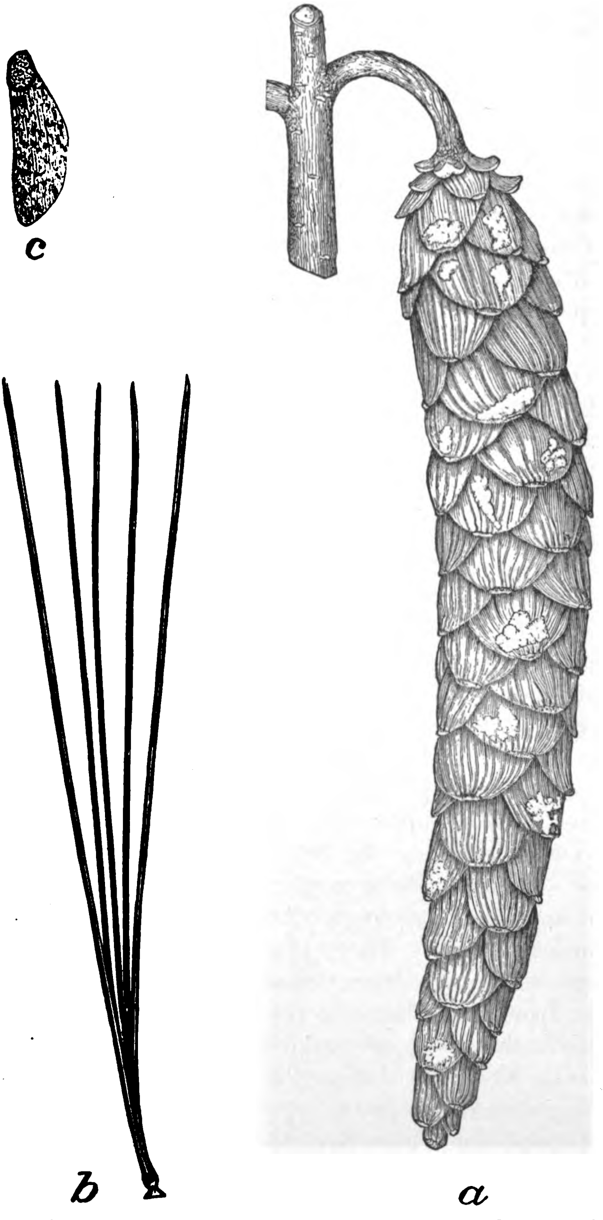


FIG. 1.—White Pine: *a*, Closed mature cone; *b*, leaf bundle; *c*, seed. (Natural size.)

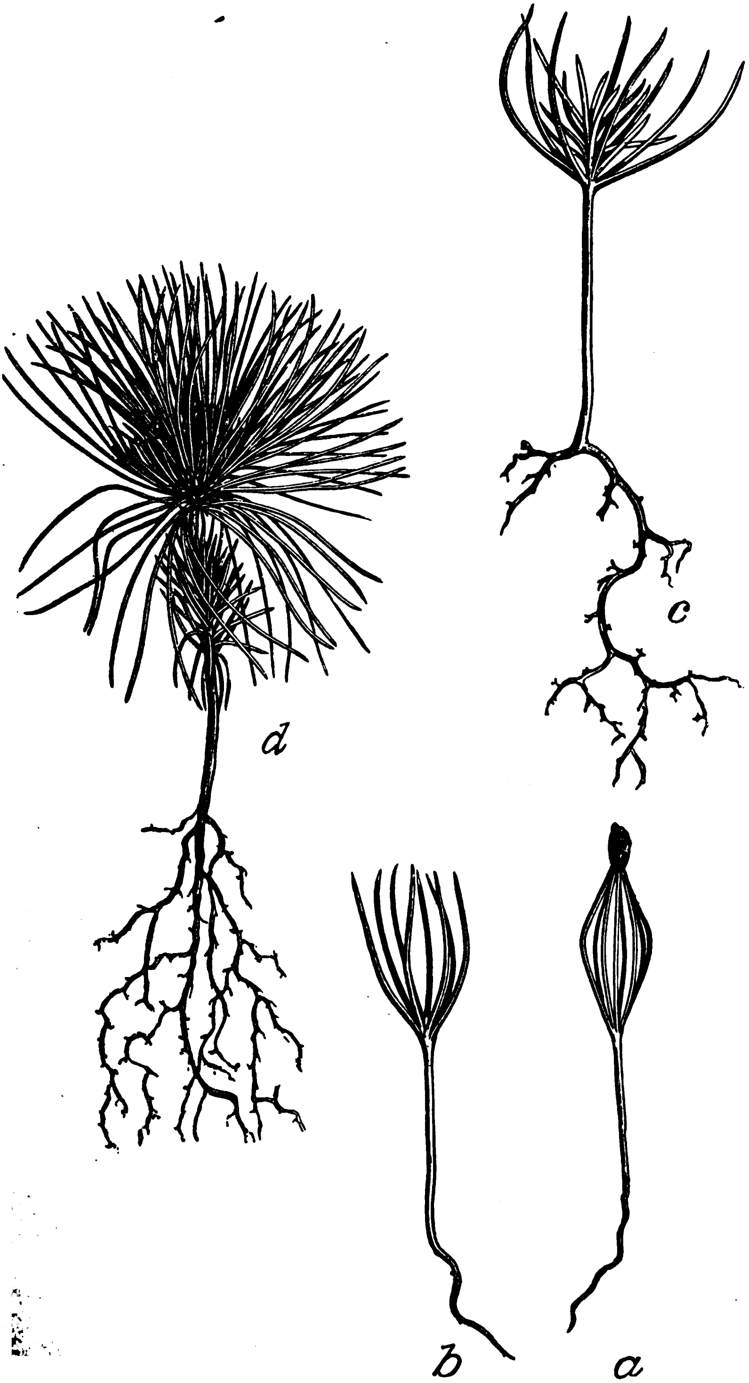


Fig. 2.—White Pine: *a*, *b*, *c*, *d*, development of seedling from germination to the second year.

rich moist soils and in very dry or poor soils. Stock raised from seed trees growing under either of these extreme conditions usually does better if placed in a soil similar to the one in which its parents grew. There are, however, some exceptions to this. Thus the Eastern Larch, which grows exclusively in moist mucky swamps, may be propagated in loose upland soils. As a rule, plants from seed trees grown in poor dry soils do well in rich moist soils, while plants from seed trees grown in rich moist soils are less at home in poor dry soils.

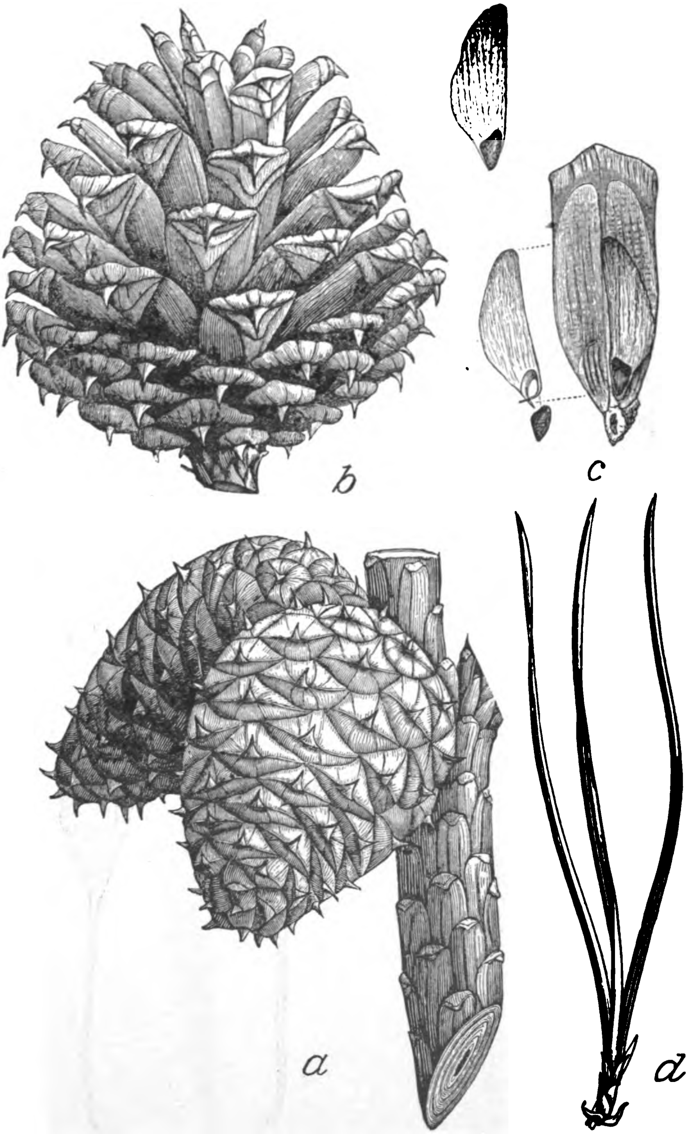


FIG. 3.—Pitch Pine: *a*, Closed and, *b*, open mature cones; *c*, lower side of detached cone scale and seeds; *d*, leaf bundle. (Natural size.)

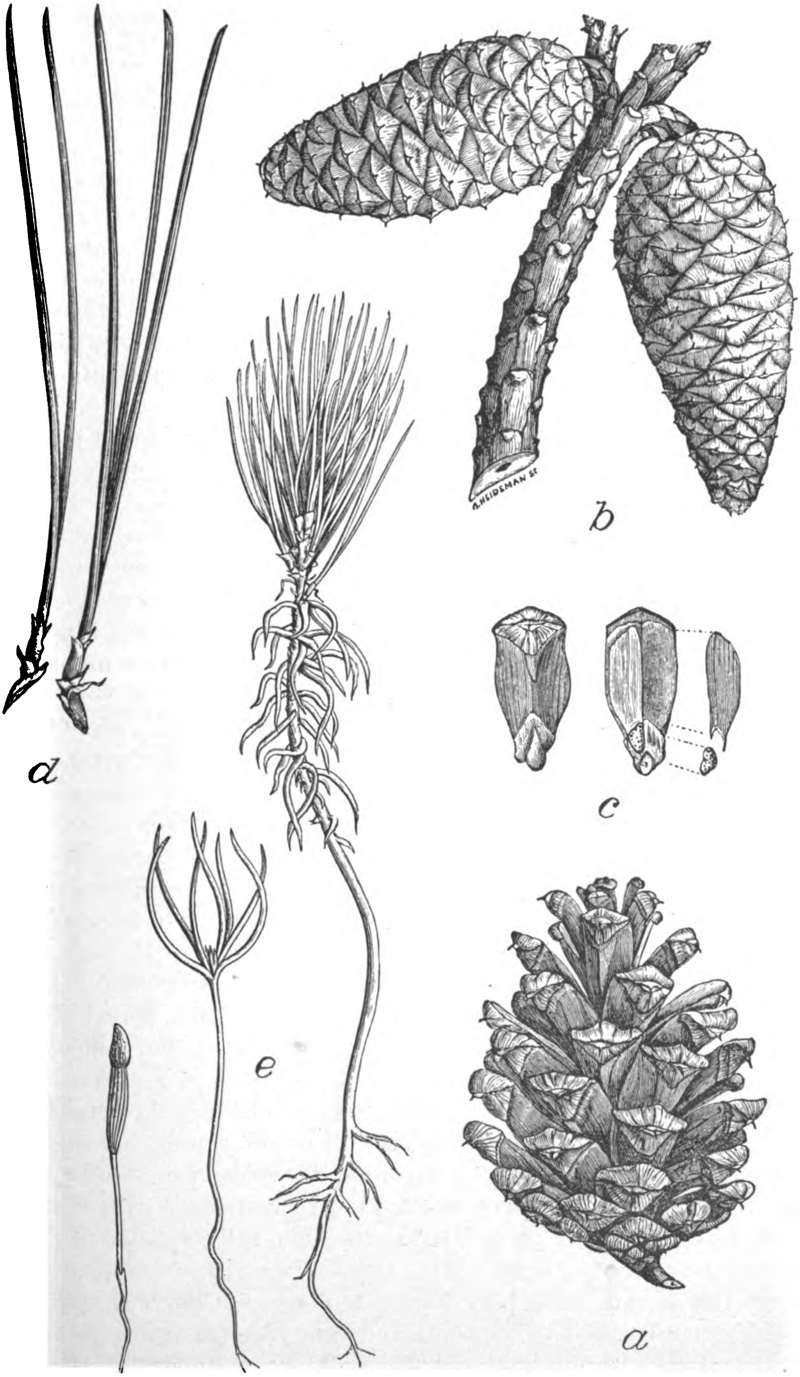


Fig. 4.—Shortleaf Pine: *a*, Open and, *b*, closed mature cones; *c*, upper and lower sides of detached cone scale with seed; *d*, leaf bundles, showing variation in the number of leaves; *e*, development of seedling from germination to first year. (Natural size.)

WHEN TO COLLECT SEEDS.

A few kinds are collected from April to July; the majority of tree seeds are gathered from September to November. Do not fail to collect seed during a prolific seed year. Watch should be kept to see that squirrels and other animals do not carry off the seed crop first.

The time for collecting forest tree seeds varies from April to November, according to the kind and the region in which they are grown; a few pines with cones which open tardily, such as the Jack Pine, Pitch Pine, Lodgepole Pine, etc., may, except for the cold to which the collector is subjected, be secured during the winter. It is possible also during the winter to collect the seeds of Boxelder, Black and Honey Locust, Kentucky Coffeetree, Ashes, Catalpas, and others, since a large part of the crop may often cling to the trees for several months. (See frontispiece.) Large quantities of Honey Locust and Kentucky Coffeetree pods are usually thrown down by wind during the fall and early winter, and may then be easily picked up (see Pl. I, fig. 1). Care must be taken that hogs or cattle do not destroy locust pods before they can be gathered. It is not well, however, to depend too much upon winter collecting, for then the presence of seeds is largely accidental. Several broadleaf trees, such as Red and Silver Maple, and Elms, mature their seeds in the spring or early summer months, but the majority of tree seeds are ripe from September to November.

It is important to observe that seed production with some trees is variable. Few trees bear a full crop of seed annually, but usually at intervals of two to three years, or occasionally at longer intervals. Seed should, therefore, be gathered from trees whenever they bear a good crop, for the next year's crop may be small, or the seeds may be imperfect, or it may fail altogether. It sometimes happens, from no apparent cause, that the seed borne by a tree is much more perfect one season than another.

No rules can be given for the exact time when tree seeds should be collected. By studying the table on pages 60–63, which indicates months in which certain species ripen their seed, the collector can ascertain approximately when to look for seeds.

Care should be taken not to gather seed until it is thoroughly ripe. This may often be more or less difficult to determine; but the brown and yellow tints assumed by ripening tree fruits are quite readily recognized as indications of maturity. In addition to these external signs, ripeness will be recognized in the firm, full condition of the seed when cut or cracked open. The well-known ripened appearance of pulpy fruits, such as Apples, Haws, Mulberries, Cherries, will always indicate mature seed. The cones and cone-like fruits are exceptional in not always giving external signs of the maturity of their concealed seeds. Thus the cones of the Pines, Spruces, Firs, Larches,

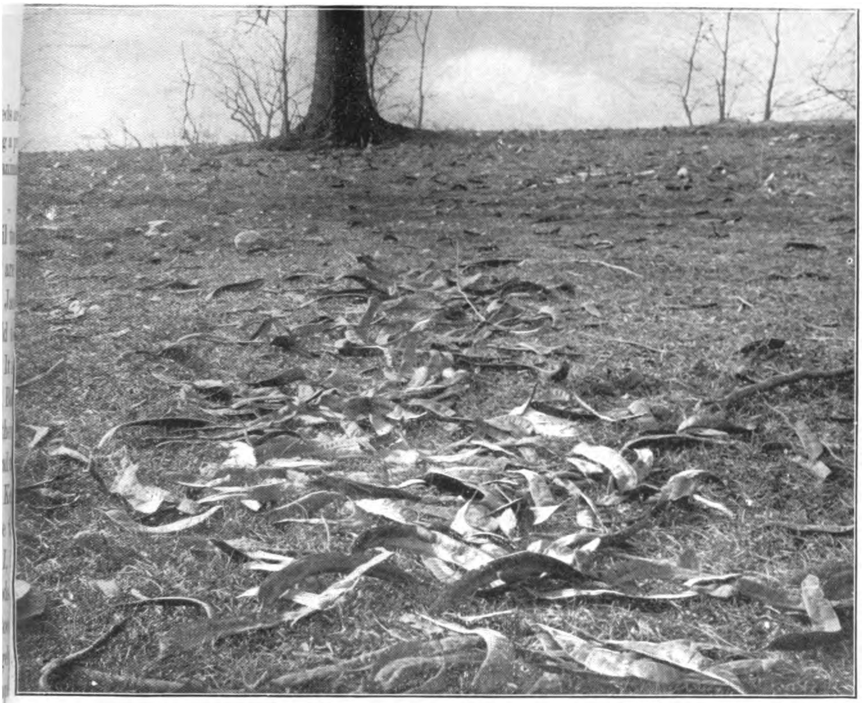


FIG. 1.—HONEY LOCUST SEED PODS THROWN BY WIND, SHOWING OPPORTUNITY FOR SECURING SEEDS EASILY IN MILD CLIMATE, DECEMBER. MARYLAND.

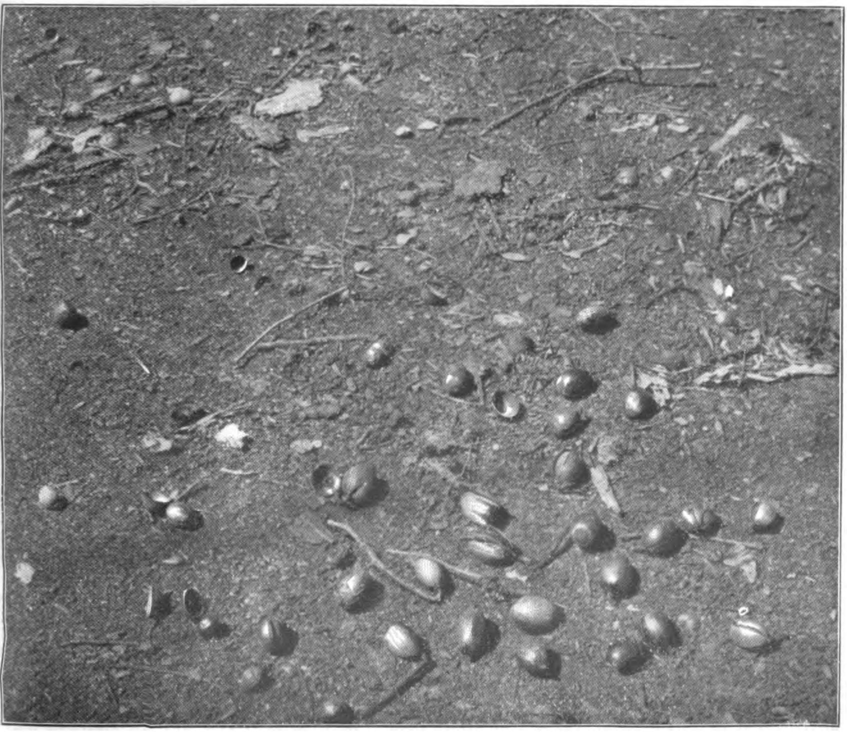


FIG. 2.—CHESTNUT OAK ACORNS AFTER AN EARLY SPRING FOREST FIRE HAS BURNED OFF THE PROTECTING COVER OF LEAVES, SHOWING THE GERMINATION LAST FALL OF SEVERAL ACORNS UNDER THIS PROTECTION. MARYLAND.

Hemlocks, Cypress, Arborvitæs, Birches, Alders, and Tulip-tree have mature seeds under their scales from one to several weeks before the cones

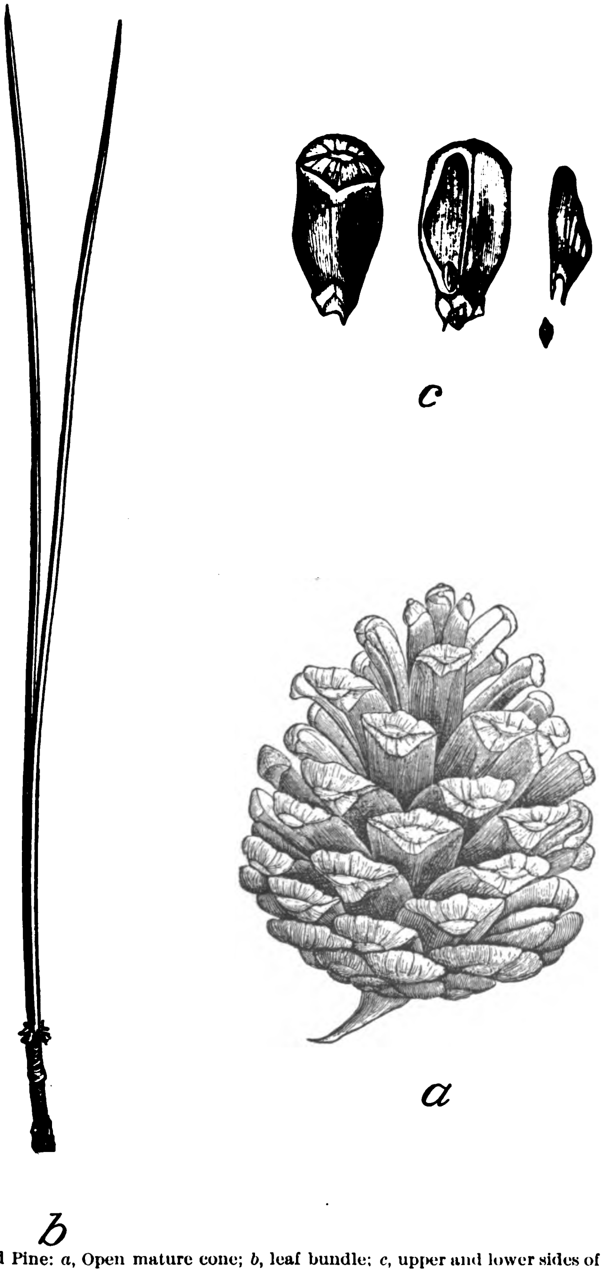


FIG. 5.—Red Pine: *a*, Open mature cone; *b*, leaf bundle; *c*, upper and lower sides of detached cone cales with seeds. (Natural size.)

appear to be ripe; in fact, cones with ripe seeds may appear quite green externally (see figs. 1, 3, 4, 6, 7). The ripeness of seeds in cones of immature appearance can be quickly determined by cutting through the cones at various angles with a sharp knife. If the seeds

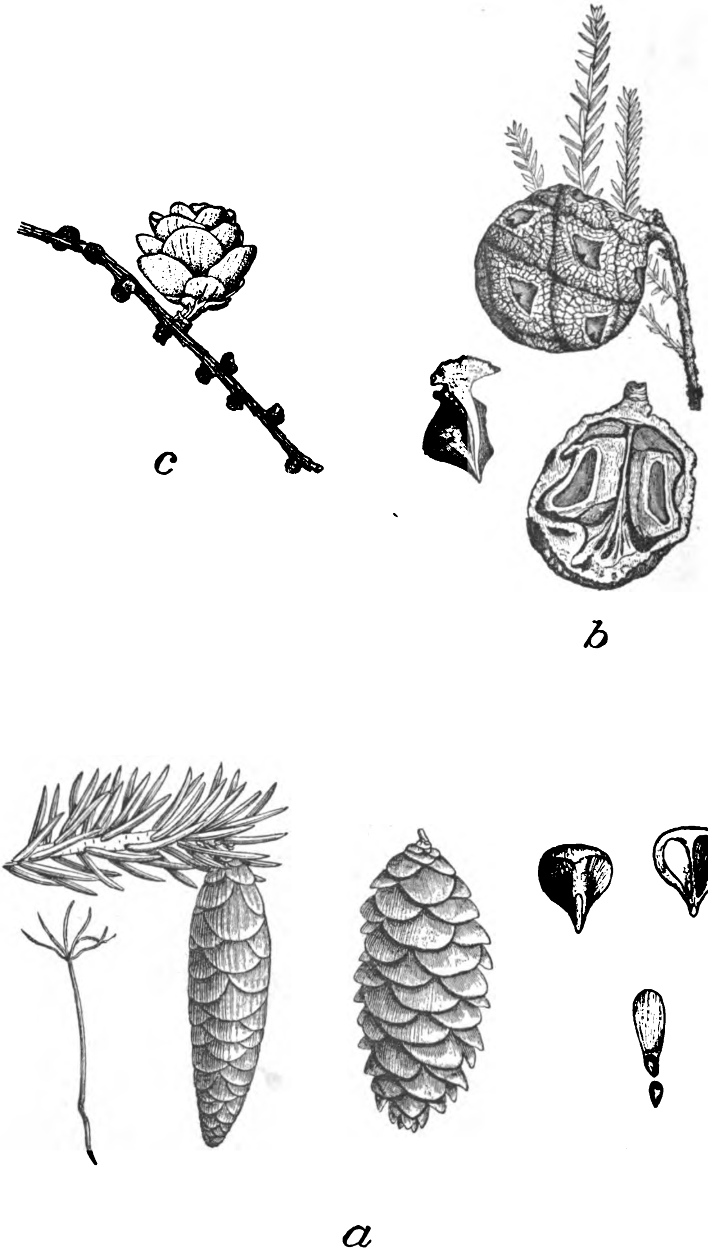


FIG. 6.—Cones and seeds: *a*, White Spruce, closed and open mature cones, and upper and lower sides of detached scale and seed (seedling 10 days old); *b*, Bald Cypress, mature cone, section of same, and detached seed; *c*, open mature cone of Tamarack. (Natural size.)

be ripe, the full whitish flesh of the cut seeds will be seen between the overlapping cone scales; the coverings of the seeds will also have brownish, mature appearance, in contrast with the greenish cone scales. If these signs be present collecting should begin at once.

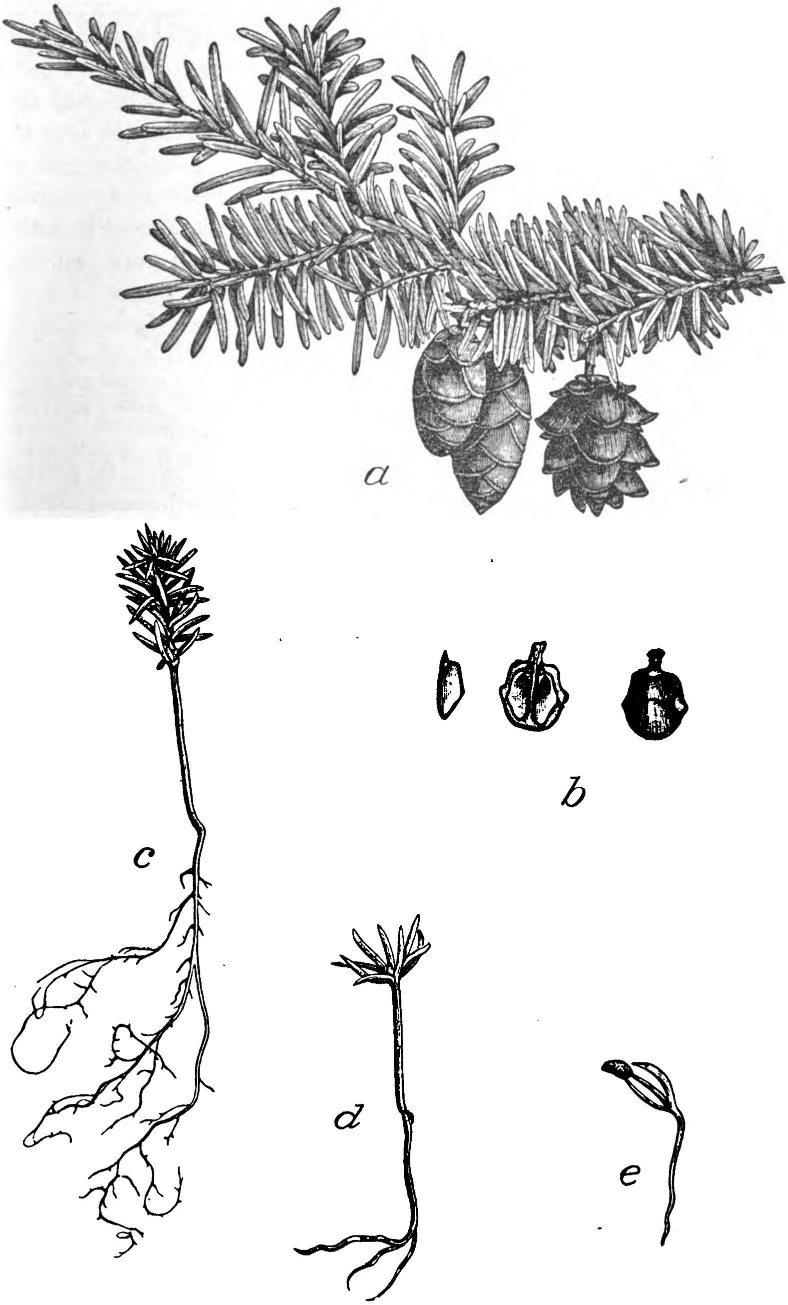


Fig. 7.—Hemlock: *a*, Branchlet with open and closed mature cones; *b*, upper and lower sides of detached cone scale and seed; *e*, *d*, *c*, development of seedling from germination to first year. (Natural size.)

If left to dry on the trees the mature cones of the Bald Cypress, Firs, Birches, and Tulip-tree will soon lose their seeds by falling to pieces, while the cones of Pines (excepting species with close cones), Spruces, Larches, Hemlocks, Cypresses, and Arborvitæs with persistent cone scales, will lose their seeds by the opening of the scales (see figs. 3, 4, 5, 6, 7). The pine squirrels are knowing collectors, and begin to cut the pine, spruce and fir cones before they open and lose their seeds. All such cone fruits should therefore be promptly gathered as soon as the seeds are found to be well matured. In the western mountain regions, where the seeds of conifers are eaten so extensively by squirrels, it is especially important to keep watch and gather the cones before these animals get them.

WHERE TO COLLECT SEEDS.

Field or roadside trees bear the largest crops of seeds, and their crowns are low and easy of access. Trees in open forests and on the borders of denser growths are the next most desirable, but are more difficult to collect from.

Among broadleaf trees the greatest amount of seed is produced by those growing in the open, where, in the full enjoyment of light they develop low, broad crowns. Every country lad knows that the Hickories and Walnuts growing in fields and fence corners bear the best and the largest quantities of nuts. The low stature of these field trees will also afford the easiest collecting.. If none of these are at hand, trees along the border of a forest and those in an open or scattered stand will give the next best supplies of seeds, but on account of their usually greater height of crown forest-grown trees will be more difficult to collect from.

Among conifers also scattered trees and those in an open forest are generally more productive of seed than trees in a dense stand. But such conifers as Spruces, Firs, Larches, and Arborvitæs, which have narrow conical crowns, bear seed chiefly at the top, and are therefore very productive even in a moderately close stand.

It is important to note that the difficulty of collecting some coniferous seeds is much less among mountain-grown trees. This is especially true of conifers in the western mountain regions. It would be quite impossible to collect seed from some of the lofty Sugar Pines, Yellow Pines, and Firs of those regions except by felling the trees. At high altitudes, however, low, stunted trees may often be found heavily loaded with cones which are easily gathered. The cones of such trees are quite as large as those on taller trees, and the quality of the seed appears not to be inferior.

It is fitting to remark in this connection that farmers will find it most profitable to encourage the growth of any forest trees which chance to spring up in fence corners, and to a limited extent in fields, for the purpose of seed production. A supply of at least a few kinds of tree seeds could thus be had at home.

Walnuts, Butternuts, Hickories, Oaks, Beeches, Cherries, Elms, and Maples are familiar shade trees scattered over many farms in the natural range of the species and are valuable for the seed they produce. Every farmer, at least in the naturally wooded States, could, without much trouble, maintain a full collection of indigenous trees planted or allowed to spring up in fence corners and waste places for the purpose of seed production. With a more general demand for tree seeds some profit would eventually be derived from such a stock.

HOW TO COLLECT SEEDS.

Small seeds (of Ashes, Maples, etc.) and cones must be picked from the trees by hand, and are, therefore, the most difficult to collect. Large seeds (acorns, hickory nuts, walnuts, beechnuts, etc.) can be gathered after they have fallen. Cutting down trees or lopping branches or tops to get seed is destructive to seed trees, and should not be resorted to.

Tree seeds must be collected chiefly by hand picking. Certain classes of them, such as the seeds of the Oaks, Hickories, Walnuts, Butter-

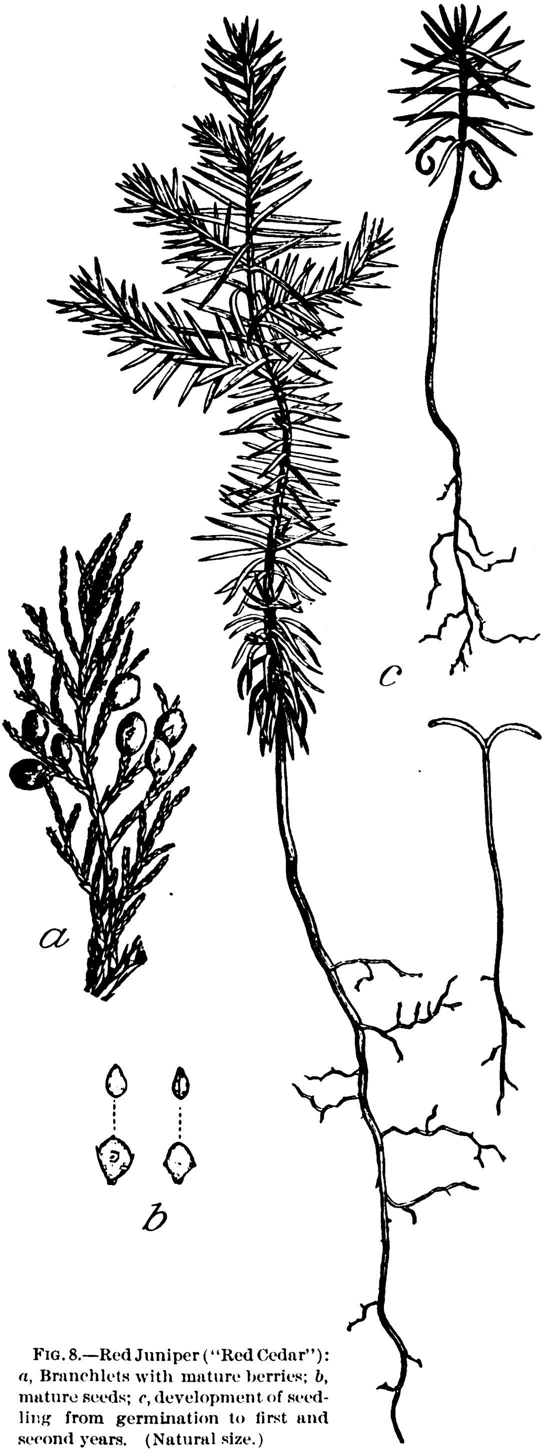


FIG. 8.—Red Juniper ("Red Cedar"): *a*, Branchlets with mature berries; *b*, mature seeds; *c*, development of seedling from germination to first and second years. (Natural size.)

nuts, Chestnuts, and Beeches, which fall readily with wind and severe frosts, can be collected with less difficulty than other tree seeds, since they need only to be gathered from the ground (Pl. I and fig. 11). The hulls of beechnuts are usually opened by successive frosts, and often hold the nuts for several days, during which they can be whipped or shaken from the tree and caught on sheets or blankets spread underneath.

The seeds of the Ashes, Maples, Boxelder, Cherries, Hackberries, Locusts, Elms, etc., together with all cones, should be picked from the tree by hand (see frontispiece and fig. 8). When the trees stand on smooth ground, Silver Maple seed may often be secured after they have fallen. The seeds are so large and usually so abundant that they can be easily raked up (see figs. 9 and 10). There are also occasional opportunities of securing Maple and Ash seeds which have fallen into streams and have been thrown ashore in little "drifts."

The temptation to cut off large branches, or the leaders of Firs and Spruces, or even to cut down certain trees to get the seed should always be resisted, except when the trees are at the same time wanted for timber. An occasional judicious pruning of small branches (cutting off 1 to 2 feet) to secure difficult clusters of seed will do no harm, and in the case of many roadside or field trees a general pruning may even be desirable to keep a spreading crown within proper limits. With broadleaf trees the effect of such trimming is quickly repaired by new shoots. On the other hand, the leaders of Spruces and Firs, which bear the bulk of the cones, should never be cut off for the sake of securing the seed. Permanent injury is likely to result from decay admitted at the point where the top is cut off; in addition, the place of the leader is not always fully supplied by a lateral top branch bending and growing upward. At best the new leader is bayonet shaped and in danger of being stunted.

Pruning shears mounted on a long pole will be useful for clipping off broadleaf branchlets too high to be otherwise reached with safety. A pair of climbing irons, similar to those used by telegraph linemen, with rounded, chisel-pointed spikes are used by professional seed collectors, and greatly facilitate the climbing of both tall and low trees.

PRELIMINARY TREATMENT AND CARE OF FRUITS AND SEEDS.

Cones of Pines, Spruces, Hemlocks, Larches, Cedars, Cypresses, and Alders are dried till the scales open, when the seeds are whipped out. Pulpless pods (Black Locust, etc.) are treated similarly. Cones of Firs, Birches, and Tulip-tree are dried till they fall to pieces, and the seeds are sifted from the scales. Pulpy pods (Honey Locust, etc.) and pulp fruits are macerated in water till the seeds can be washed out. Thick hulls of nuts are removed. Most seeds and nuts require superficial drying.

After they are collected, the fruits of many trees, such as the cone-bearers, a few Oaks and Hickories, Osage Orange, Walnuts, Butternuts, Mulberries, Locusts, Kentucky Coffeetree, Cherries, Apples, and others require special treatment to separate the seeds from the pulp or hulls, or to fit them for keeping till they are sown. This treatment consists in drying cones and some other fruits as nuts, or in macerating pulpy pods, cherries, plums, and berries, till the seed can be washed out. The drying can be done out of doors in the sun or in a warm room. An artifical heat of 70° to 75° F. will be sufficient. High temperatures injure the vitality of the seeds.

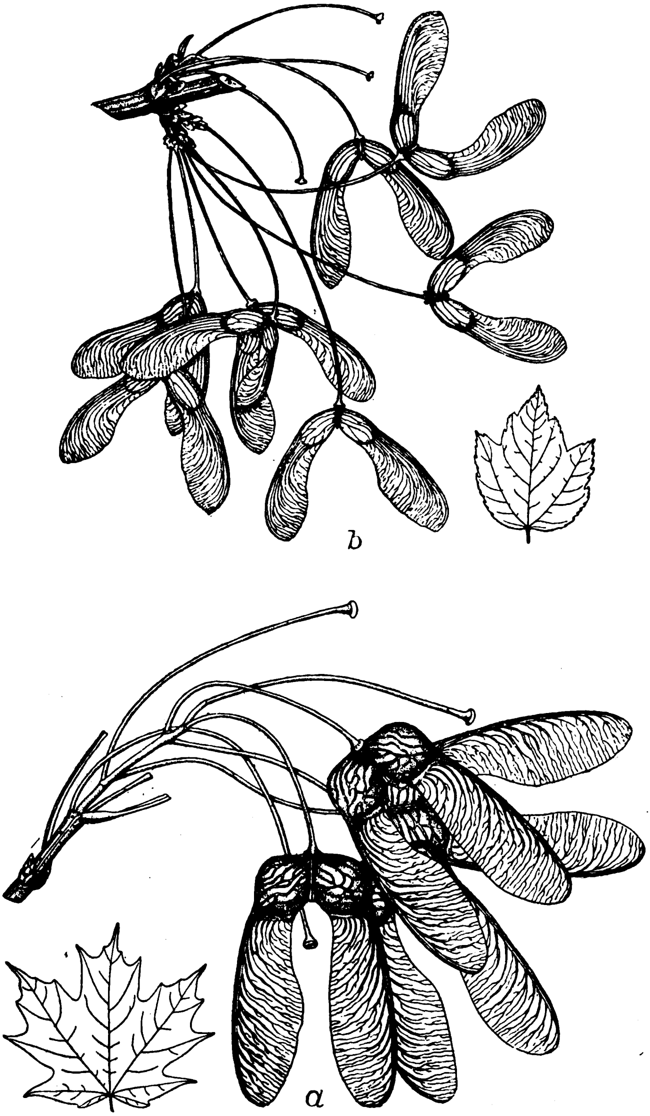


FIG. 9.—Seeds and leaves: *a*, Sugar Maple, mature seed (natural size), mature leaf (¼ natural size); *b*, Red Maple, mature seed (natural size), mature leaf (⅓ natural size).

If dried in a room, the material should be, according to the quantity

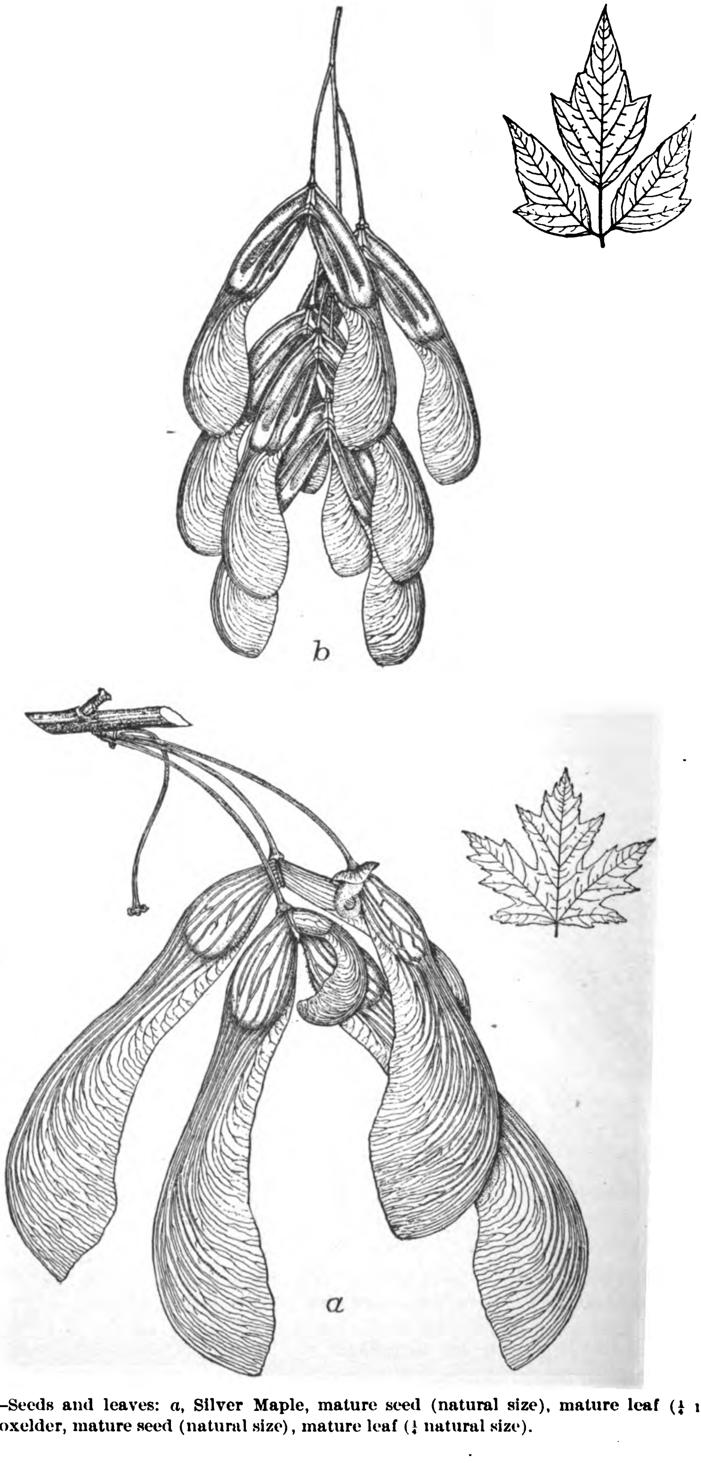


FIG. 10.—Seeds and leaves: *a*, Silver Maple, mature seed (natural size), mature leaf (¼ natural size); *b*, Boxelder, mature seed (natural size), mature leaf (¼ natural size).

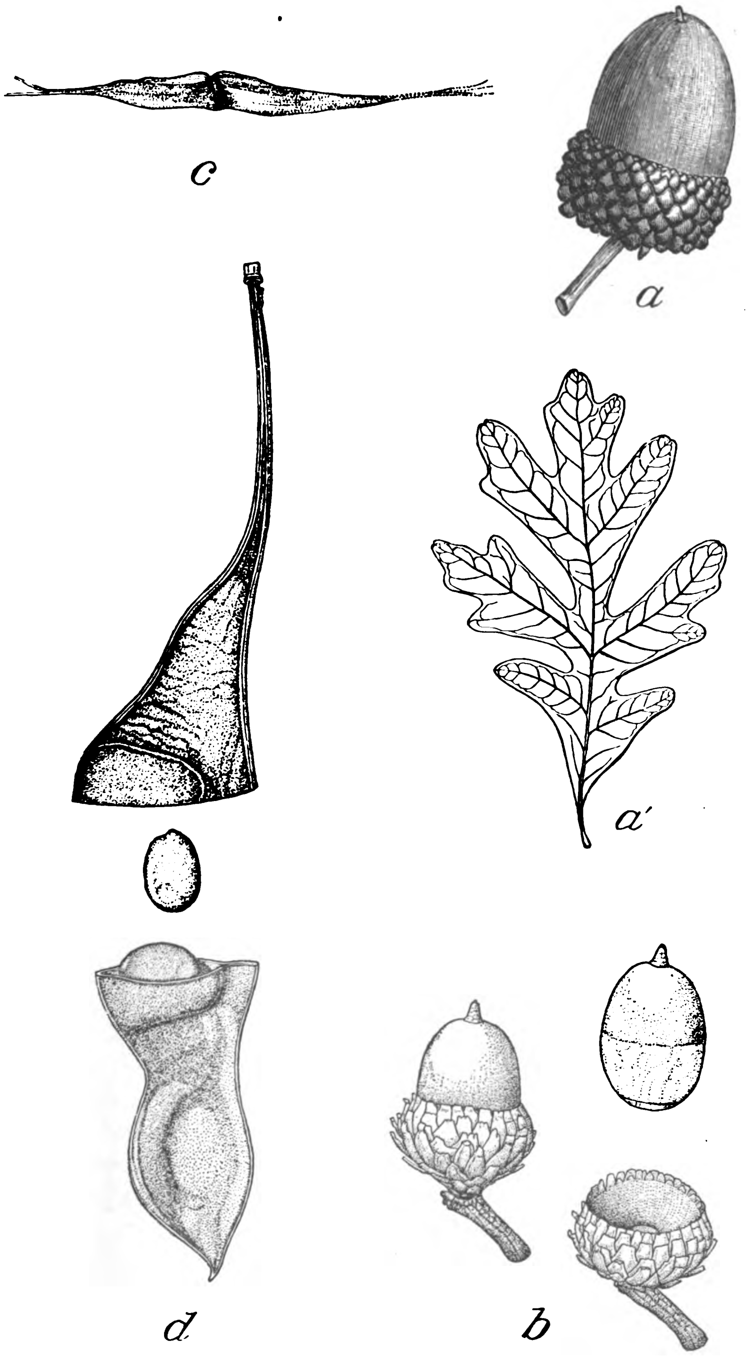


Fig. 11.—Acorns, leaf, seed, etc.: *a*, White Oak, mature acorn (natural size), mature leaf (⅓ natural size); *b*, Black Oak, mature acorns (natural size); *c*, seed of common Catalpa (natural size); *d*, Honey Locust, extremities of mature pod and detached seed. (Natural size.)

and available space, spread upon a clean, tight floor, or upon shallow tight-bottomed trays arranged one above another in racks; the nearer the latter are to the top of the room, the quicker the drying will be accomplished. If the drying is done in the sun, the material should be spread on a tight board floor, flat roof, trays, or a canvas or other sheet. Drying fruits should always be protected from rain. In out-of-door drying care should be taken also to protect the lighter seeds from being blown away as they are shelled out. The seeds of Pine, Spruce, Fir, Larch, Hemlock, Tulip-tree, and others, are easily disturbed or carried away even by a light breeze.

When the cones of Pines, Spruces, Hemlocks, Larches, Arborvitæs, Cedars, Cypresses, Sequoias, and Alders are thoroughly dry the scales will open out and liberate the seeds. The extracting of the seeds will then be greatly hastened by whipping the cones or brushing them about briskly, till all the seeds have fallen out. As a rule very little jarring is required to dislodge all the seeds from dried White Pine and other thin-scaled cones. The same is true of the Spruces, Hemlocks, Larches, and Arborvitæs.

The labor of separating seeds from the small cones of such species as Arborvitæs, Cedars, and Cypresses may be shortened by sifting the mass of seeds and cones with a sieve of the right size to let the seeds through and retain the cones.

A few species, such as the Jack Pine, Table Mountain Pine, Pitch Pine, Lodgepole Pine, Pond Pine, Sand Pine, Knobcone Pine, have thick, strong scales, which in nature often remain closed for several years, in some instances never opening at all. Such cones require careful and thorough drying to open the scales, which, however, rarely fail to open when a sufficient degree of dryness is reached. Cones of this character are best dried in a warm room. The huge, strong cones of the Gray Pine and Coulter Pine should also be dried in a warm room. Even when these cones are completely dried, the scales do not always open sufficiently to liberate the seeds. It will then be necessary to split or cut the cones in order to get the seeds out.

When the cones of Firs, Tulip-tree, and Birches are sufficiently dry, they will fall to pieces completely, forming a mass of seeds and cone scales. The quickest and most economical way of separating the seed is to sift the mixture through a wire sieve with meshes of the proper size to retain the scales and let the seeds through. A few trials will determine the right-sized mesh.

The pulpless pods of the locusts, and other species with similar fruits, yield their seeds readily when dried and flailed or whipped on a tight board floor, or a sheet laid on the ground.

The pulpy pods of the Honey Locusts and Kentucky Coffeetree should be cut or broken into pieces and macerated in a tub of water till the seeds can be washed out (see Pl. I, fig. 1). Mashing and stirring the macerated mass and washing in plenty of water will allow the loosened seeds to sink and most of the débris to float. The thick strong pods of the Coffeetree are usually partly opened by severe frosts, after which the seeds can be picked or scooped out. A thorough soaking in water also renders the pods[1] pliable, so that they can be torn open and the seeds taken out.

The fleshy fruit of the Osage Orange, Plums, Cherries, Hawthorns, and Mulberries require macerating in water until the seeds can be washed from the pulp. After the seed has been cleaned it should be spread out in a thin layer and slowly dried in the shade or in a cool, airy room.

The pulp of Cherries, Plums, and similar fruits may be removed also by macerating the fruit in water till the seed can be washed clean. The pulp of the Wild Black Cherry fruit need not be removed, but is easily dried on the seed and the latter kept without further preparation.

The thick walnut hulls are best removed as soon as the nuts are gathered. The nuts are then much less bulky. Moreover, if left on during the winter storing, the fleshy hulls become moldy, mushy, and disagreeable to the touch.

Various devices are used for "shucking" walnuts. The most rapid and efficacious method is to run the nuts through a corn sheller. Another, but slower, method is to force the fruit through an auger hole just large enough to let pass a nut of average size. A 2-inch plank is provided with four legs or blocked up flatwise about a foot high, upon which the operator sits. A nut is placed over an auger hole in the plank, a blow from a mallet or hammer forces the nut through, and the hull is cut off by the edges of the hole.

The hulls of the Shagbark, Shellbark, Mockernut, and Pignut hickories are usually removed without difficulty after the nuts begin to dry. Most of the hulls fall off in handling the nuts.

Butternuts need not be hulled, for the thin hulls dry up and add no appreciable bulk.

The Overcup and the Bur Oak, together with the Bitternut, Water Hickory, and one form of the Pignut Hickory, retain their nuts more or less firmly in cups or hulls even when severely frozen and during the more or less rough handling in gathering. The cups and hulls of these add but little to the bulk, and may also be left on with no damage to the seed. In fact, under some circumstances, the hulls prevent the thin-shelled nuts from drying out too much.

Nearly all tree seeds, including those divested of their husks or pulp, should be superficially dried, as the superfluous moisture in the green or wet hulls and seed coats is likely to cause destructive molding. The point is to dry them a little externally without affecting the vitality of the seed kernels. Such seeds as acorns, and various nuts have the kernels moist when in a growing condition, and should not be dried enough to take up this moisture, for otherwise the vitality of the kernel will be destroyed. The seeds of Maples, Boxelders, Elms, Ashes, Poplars, and Willows require very little drying, while none of the coniferous seeds will need drying beyond that given in extracting the seeds from the cones. This preliminary treatment is considered fully under the following heading:

---

[1] The jelly-like greenish pulp between the seeds of this species should not be eaten. It is a violent narcotic poison.

STORING SEEDS.

Seeds which are ripe before midsummer should be sowed when gathered. Seed ripened in midsummer and fall should be stored till spring. All seeds to be stored should be attended to by November. Nuts and acorns can be stored in earth out doors, or in cold caves or cellars. Small seeds, except conifers, may be stored in boxes in thin layers between layers of sand, the boxes being buried outdoors or kept in a cold cellar. Place conifer seed in sacks and hang up in cold cellar or outbuilding. Inspect often to prevent ravages of mice, etc.

GENERAL REMARKS.

The keeping of tree seeds in such a condition that they will germinate when planted is one of the most difficult problems. Some seeds will retain their vitality for one or more seasons when stored in an ordinary grain room, while others will lose their vitality completely under such conditions in a few months, or even in a few days.

A study of nature's wasteful but successful method of carrying seeds through the winter may afford some suggestions. Moreover, the proper storing of tree seeds is closely connected with the consideration of when to plant them.

Nature sows her seeds as they are ripened—from April to March; some all at once, and others a few at a time. If not destroyed, the majority of the seeds remain buried beneath the grass or leaves and germinate the following spring, or a season later. Acorns sometimes germinate in the fall during protracted warm weather. (See Pl. I, fig. 2.) The seeds of a few trees, however—the Red and Silver Maple, River Birch, Elms (Cedar Elm excepted), Poplars, and Willows, which ripen and fall to the ground before the end of June, germinate shortly afterwards.

EARLY MATURING SEEDS.

To keep the latter class of seeds till the following spring would be almost impossible, for their very transient vitality would be destroyed by drying or molding during the hot summer months. Such seeds should be planted as soon as they are gathered.

LATE MATURING SEEDS.

We have to consider here the storing of such seeds only as ripen from late summer to fall, together with a few kinds which ripen in midsummer, but which can be safely stored till spring.

General consideration.—While some late maturing tree seeds will germinate if planted shortly after they are gathered, others will not grow until subjected to freezing, or in some cases grow more readily after they have been frozen. Others, again, endure freezing without harm, but germinate equally well if not frozen. Several kinds retain their vitality in a comparatively dry state for a number of months or years, but require one or two years' contact with the soil before they will germinate. A few others will not retain their vitality except in contact with the ground, and even then will not germinate till the second season. It is evident, therefore, that all seeds can not be properly stored under the same conditions, but that the special needs of certain kinds or classes of seeds must be carefully supplied.

In general, the essential conditions for successfully storing tree seeds are, for some a cold, moist atmosphere, and for others a cool, dry atmosphere, such as will not allow heating and molding or stimulate premature germination, either of which would be destructive of vitality.

A tabular list of desirable native trees is given on page 60–63, in which the proper storage is indicated for each kind of seed. The following detailed account of the methods of storing seeds will also be useful:

Preliminary storage.—Most tree seeds will be gathered some days or weeks before it is time to store them permanently for the winter (November). During the early fall the seeds to be wintered are best spread out for temporary storage in thin layers in some cool, airy place, such as under a north shed, in the lower story of a barn, or on the upper shelves of a dry, airy cellar. Nuts and acorns are preferably kept on an earthen floor. All should be examined from time to time to see that they are not drying out too much or heating and molding. Close attention is necessary mostly for nuts, acorns, and maple seed. Excessive drying will be detected by cutting or breaking open the seed, which, if in good condition, should be plump and moist. Any shrinking of the seed kernel indicates a drying out. If drying too much, a sprinkling of clean sand, chaff, or straw, or a light cloth cover, will check the drying. If the seeds are heating or molding, spread them out in thinner layers.

Permanent storage.—For permanent winter storage, nuts and acorns are best placed in earth out of doors, and this should be done before the ground is frozen; or for regions where the ground remains open more or less during the winter storing should be completed by the end of November.

As soon as the weather becomes cool, and before the ground is frozen, a shallow pit (3 to 6 inches deep) should be scooped out on a well-drained site, preferably on a little rise of ground to insure perfect drainage of surface water. The nuts and acorns are to be placed in this excavation, and as many shallow divisions should be made in the space as there are different kinds of seeds, in order that each kind may be kept by itself. Spread out each kind in its own place, making the layers 2 inches deep for the smaller seeds and 6 inches for the larger kinds. Cover all with 6 to 12 inches of leaves, chaff, or straw, and over this place 4 to 6 inches of earth. To prevent the earth from washing, a cover of boards, slabs, or poles should be added. The outer edges of the pit should be protected with an extra heavy layer of earth in order to exclude mice, rats, or other rodents, which are likely to discover the stores and do considerable damage. An occasional inspection of the edges will be advisable to insure safety from such attacks.

Any freezing which takes place during the winter storage will not damage the seed, but will be helpful in opening the hard shells.

If a deep, cold cave, such as can be tightly closed during winter, is available, it will be an excellent place to store nuts and acorns. They can be spread out in piles on the earthen floor and left till spring. It will be advisable, however, occasionally to examine seeds thus stored to see that they are keeping properly and are not being eaten by rodents.

With the exception of conifers, the smaller seeds could be stored in the same manner as described for large seeds, but they are best mixed or stratified, as directed below, with clean, moist sand, and stored in boxes, which can either be kept in a cold cellar or cave or sunk to the level of the ground out of doors, where a low, uniform temperature will be maintained.

If only a quart or so of small seed is to be stored, it can be mixed in three parts of sand to one of seed, placed in a sack or box, and stored in a cool cellar. Larger quantities of seed are best placed in a box, the seed being arranged in alternate layers (½ to 1 inch thick) and sand (2 to 3 inches deep), beginning and ending with a layer of sand. In this manner a number of different kinds can be stored in the same box. In order to avoid possible mixing, it is best to separate the different kinds of seeds by placing boards, shingles, heavy paper, or cloth between them. A board cover should be placed over the box when full. The box can then be dropped into a pit deep enough to let it down level with the ground, the spaces filled in about the box, and 6 inches or more of earth so mounded up over the top as to shed water. The box may with equal safety be stored in a cold cellar.

If, in taking out the seed in the spring, much sand is mixed with it, the latter can be removed easily by sifting. All seeds stored in sand should be planted immediately after they are taken out, for allowing them to dry will be fatal to their vitality.

Seeds of conifers and a few other seeds (Mulberry, Osage Orange, Locusts, Sycamore, Catalpas, Cherries, Hackberries, Boxelder, and Ashes) need not be mixed with sand for storing, provided they can be kept in a uniformly cold, dry atmosphere, such as that of a cellar or outbuilding. The seed may then be placed in sacks and hung up, or, if the floor is earthen, placed on a wooden shelf, to prevent the absorption of moisture; contact with a dry cement floor will not damage the seed. Seed should be examined from time to time during the winter to see that it is keeping properly.

TESTING THE VITALITY OF SEEDS.

Samples of seeds to be purchased should be tested in order to avoid receiving worthless seed. Provisional tests can be made by cutting a few seeds open and inspecting for freshness and perfection of the kernels. Absolute tests are made by sowing counted sets of seed in sand or sphagnum moss; cover seed its own depth, and keep moist. Fresh seeds germinate in from ten to thirty days.

It is often necessary to determine the vital condition of certain seeds in dry storage in order that any damaging influence in the storage may be removed. It is also of great advantage, before purchasing, to test the vitality of seeds received from irresponsible dealers and collectors. Various frauds are perpetrated, and, through the ignorance of the consumer, worthless seed may be received. Old and worthless seeds of the rarer and more expensive conifers are not infrequently sold for fresh seed or mixed with a small quantity of the latter.[1]

PROVISIONAL TEST.

The only absolutely reliable test for determining the vitality of seeds is germination. But as this requires from ten to thirty days or longer for results, it is often necessary, from lack of time, to resort to a short provisional test, which will give approximately the condition of the seed. This is accomplished quickly by cutting fifty or one hundred seeds open and observing whether the kernels are decayed, rancid, moldy, shrunken, entirely dried out, or whether they are plump, firm, and moist, as is the case with a large number of different kinds of seeds when in good condition. The seeds of Persimmons, Ashes, Locusts, and Acacias may, however, be exceedingly dry and still exhibit about the same appearance when cut open as perfectly fresh seed. To discover the exact condition of such seeds will, of course, require more experience and more careful examination than is necessary for other classes of seeds. A little close study of bony seeds known to be fresh, compared with samples known to be old, will give the necessary experience. The fresh seed has a characteristic hard but elastic firmness when cut, differing greatly from the brittle, dry condition of old or lifeless seed. The saving in detecting imperfect seed will, however, be mostly with seeds of more transient vitality than the bony seeds, which, if properly treated, are likely to prove useful even when from two to five years old.

---

[1] The Department of Agriculture is now well equipped in its Seed-Testing Laboratory for testing the vitality of all seeds distributed by the Department, and also of those which are submitted for test by correspondents at large. No charge is made for testing seeds.

ABSOLUTE OR GERMINATING TESTS.

The germinating test of fresh tree seeds usually requires from ten to thirty days, or for such seeds as the Locusts, Acacias, Junipers, Hollies, Hawthorns, and Tulip-tree sixty to ninety days, or even a year, may be required. Tests are made by sowing the seed in soil, sand, powdered sphagnum moss, on damp blotting paper, between folds of moist cloth, or in porous earthenware dishes. The tests made in sand or on sphagnum moss are the most reliable, and give the highest rates of germination.

Sand, soil, and sphagnum moss tests.—The seeds to be tested are sown in rows or broadcast in shallow boxes or pans filled with sand or soil, and are covered about their own depth; the sand or soil is then kept moist till all the seeds that will do so have germinated. For testing with sphagnum moss, similar receptacles are filled preferably with sand, although earth may be used, over which one-half to one inch of powdered sphagnum is placed. The moss is moistened and the seeds sown on top. The sphagnum is to be kept moist till germination ceases.

These two methods, employing either sand alone or sphagnum and sand together, give the highest rate of germination for small seeds, especially conifers, doubtless for the reason that the moss and sand supply an even amount of moisture. Moreover, the sand cultures are least liable to attacks of the molds so common under the warm and moist conditions necessary to maintain for germinating tests.

At least 100 seeds should be used as a test for each kind, while for very thorough tests from 200 to 500 seeds should be sown, limiting each test to 100 seeds.

Other tests.—The testing of seeds by sowing them on constantly moist blotting paper, between the folds of moist cloth, or in porous earthenware dishes which absorb moisture, is efficacious, but not superior to the simpler and more natural methods described. The writer, at least, with other conditions unchanged, has uniformly obtained the higher rates of germination by using the sand or sphagnum tests.

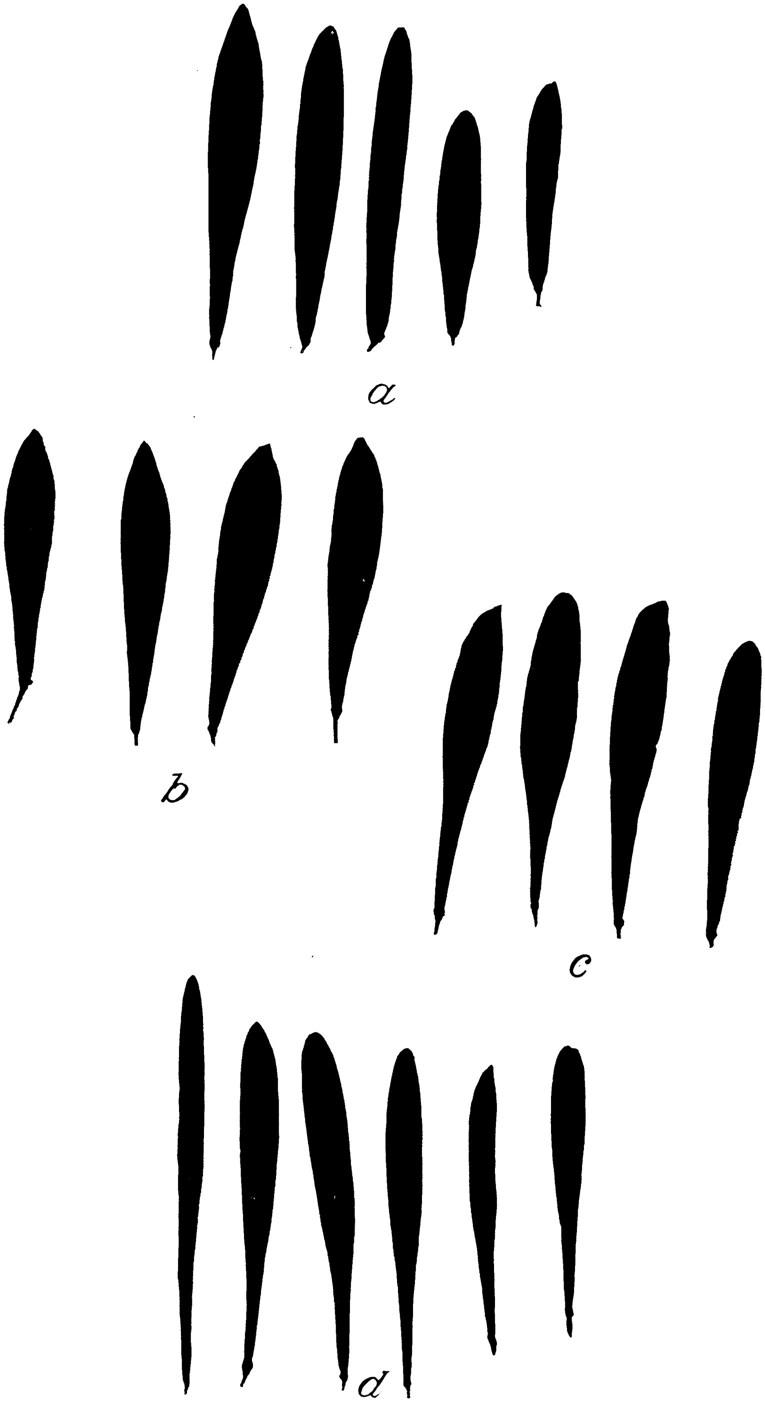
Seed testing operations are usually carried on during the winter, before it is time to sow seeds out of doors. A greenhouse is an ideal place for such tests, but a room with one or more sunny windows, in which to place the seed boxes, will answer the purpose. The temperature may vary from 70° to 80° F.

IDENTITY OF TREE SEEDS.

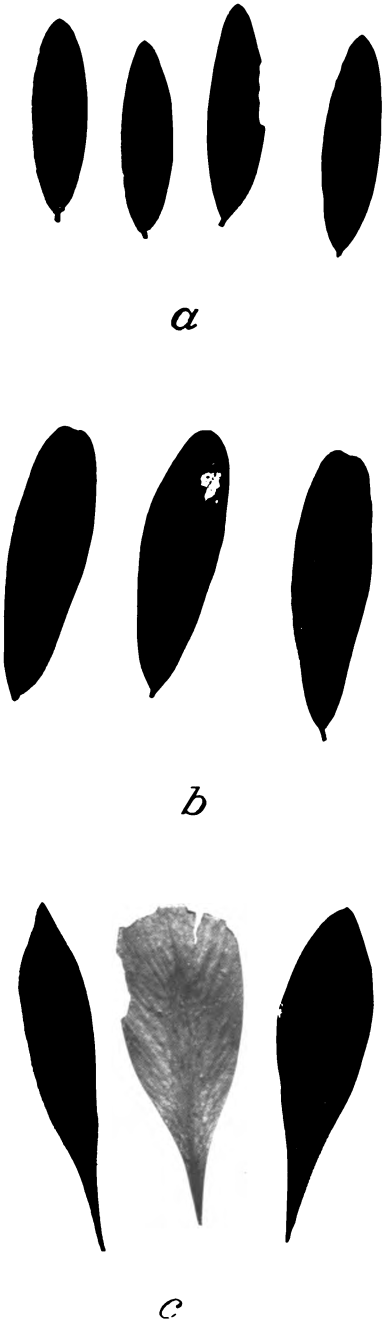
Purchased seed is often fraudulently named. When seeds are unknown or there is doubt as to their identity, planters are urged to send samples to the Department of Agriculture for identification.

The identity of tree seeds is of great importance to the planter. Either through ignorance or by intent, abundant and easily collected

PLATE II.



VARIATION IN SIZE AND FORM OF SEEDS: *a*, WHITE ASH SEED; *b*, OREGON ASH SEED; *c*, RED ASH SEED; *d*, GREEN ASH SEED. (NATURAL SIZE.)



Common variation in size and form of seeds: *a*, Blue Ash seed; *b*, Black Ash seed; *c*, Water Ash seed. (Natural size.)

species of seeds are not infrequently substituted by dealers and professional collectors for similar but scarcer kinds; or several similar kinds may be mixed and sold for one kind. The planter may thus receive the seed of inferior trees, or of those entirely unfitted for his purpose.

Some Pine, Spruce, and Fir seeds are so similar in general appearance as to pass for the same thing. Some of the Hickories, Oaks, Ashes, Elms, Catalpas, Magnolias, Basswoods, and others are also easily confounded. (Pls. II and III). The seeds of White, Green, and Red Ash are very often mixed or one sold for the other, especially where the trees grow in the same locality. White, Black, and Red Spruce seed may be easily confounded, as also the Blue and Engelmann Spruces of the Rocky Mountains. The Blue Spruce is much the more easily collected.

The ability to recognize the various tree seeds is of course attainable only by long and careful study, such as the farmer can scarcely have time for. Those collecting, buying, or receiving tree seeds by exchange are, therefore, advised to send samples of unknown or doubtful seeds to the seed-testing laboratory of this Department, where they will be properly identified and tested without charge.

VITALITY OF TREE SEEDS.

Seeds of Maples, Elms, Ashes, Poplars, Willows, and Nuts, Acorns, etc., retain their vitality for from two weeks to six months. Those of Locusts, Acacias, and similar seeds, Alders, Tulip-tree, Hollies, and Pine seeds in cones, preserve their vitality for from seven to nine years.

Allusion has been made to the length of time for which tree seeds retain their vitality. Without considering here the conditions under which the vitality of seeds may be more or less prolonged, it may be said that certain classes of seeds have a characteristically transient, or more lasting, but gradually decreasing vitality. The seeds with the shortest duration of vitality are those of the Maples, Elms, Birches, Poplars, and Willows, some surviving only a few weeks, and others scarcely from fall to spring. The Hickory nuts, Walnuts, Butternuts, Beechnuts, Acorns, Chestnuts, and Buckeyes survive scarcely a season. Among those to retain life the longest are the seeds of Locusts, Yellow-wood, Kentucky Coffeetree, Redbud, Alders, Tulip-tree, and Hollies, but they show a decrease in vitality in from one to two years. The Pine, Spruce, and Juniper seed retain vitality about the same length of time, but if kept in their cones, some of the Pines with close cones (Lodgepole Pine, Table Mountain Pine, Pond Pine, and others) have been known to give a small per cent of germination when the seeds were 7 to 9 years old.

HIGH AND LOW GERMINATION OF SEEDS.

Nut trees, Oaks, Pines, Spruces, Junipers, Cherries, Ashes, Elms, Catalpas, etc., have 50 to 90 per cent of perfect seed. Firs, Cypresses, Maples, Lindens, Tulip-tree, etc., have 5 to 50 per cent of perfect seed.

The amount of good seed produced by trees varies for different species, and also from season to season. A knowledge of this variability is both interesting and of practical value to the planter, who will otherwise often be at a loss to account for the high or low germination of the seeds. At best some kinds of trees produce a very small per cent of perfect seed, while other kinds bear a high per cent. Barring the ravages of insects, which may often ruin large numbers of seeds before or soon after maturity, the nut-bearing trees, Oaks, Pines, Spruces, Junipers, Plums, Cherries, Ashes, Elms, Catalpas, and others, bear a high per cent of perfect seed, the range being from 50 to 90 per cent or more. Seeds of the Pines and Spruces are among the most perfect, fresh seed sometimes giving a germination of 90 to 98 per cent.

Among trees which bear a low per cent of perfect seeds are the Firs, Cypresses, Maples, Lindens, and Tulip-tree, running from 5 to 50 per cent, or sometimes more. The Tulip-tree has an exceedingly small proportion of good seed (5 to 10 per cent).

PERCENTAGE OF GERMINATION.

The following table gives the approximate range in the per cent of germination for 63 important species:

Germination of tree seeds.

Name of species.	Percentage of germination in fresh seed.	Name of species.	Percentage of germination in fresh seed.
White Pine	70 to 90	Pignut Hickory	50 to 75
Bull Pine	60 80	River Birch	65 80
Shortleaf Pine	50 75	Yellow Birch	65 80
Loblolly Pine	50 80	Sweet Birch	65 80
Pitch Pine	60 85	Beech	75 95
Scrub Pine	50 80	Chestnut	75 95
Lodgepole Pine	60 85	White Oak	75 95
Banksian Pine	75 90	Bur Oak	75 95
Longleaf Pine	50 70	Chestnut Oak	75 95
Monterey Pine	75 98	Red Oak	60 80
Tamarack	50 75	Yellow Oak	60 80
Black Spruce	60 75	Spanish Oak	60 80
Red Spruce	60 75	Slippery Elm	50 75
White Spruce	60 75	White Elm	50 75
Blue Spruce	60 75	Cork Elm	50 75
Engelmann Spruce	60 75	Hackberry	70 80
Red Fir	60 75	Red Mulberry	75 90
Hemlock	30 60	Osage Orange	60 95
Balsam Fir	30 50	Tulip-tree	5 10
White Fir	40 55	Sweet Gum	50 75
Bald Cypress	25 50	Sycamore	60 75
Incense Cedar	40 65	Black Cherry	75 80
Arborvitæ	50 75	Honey Locust	50 75
Pacific Arborvitæ	50 75	Kentucky Coffeetree	50 75
Lawson Cypress	25 40	Sugar Maple	30 50
Red Juniper	50 75	Red Maple	25 60
Walnut	75 80	Silver Maple	25 60
Butternut	75 80	Boxelder	40 60
Bitternut Hickory	70 85	White Ash	35 50
Shagbark Hickory	50 75	Red Ash	35 50
Shellbark Hickory	50 75	Green Ash	35 50
Mockernut Hickory	50 75	Catalpa	40 75

PROMPT AND SLOW GERMINATION.

Seeds with thin, weak, absorbent coverings germinate quickly; those with hard, stony coverings, or of bony consistency, germinate slowly. To hasten germination soak locust and similar bony seeds in hot water three to six days before planting.

When planted in moist, finely pulverized soil different kinds of fresh tree seeds require a comparatively longer or shorter time before they germinate. The moisture and warmth of the soil may be similar for all the seeds planted, but there will be a wide variation in the time needed for germination. Some will germinate within ten days, some in one or several months, while some others may not sprout until the second season and then often irregularly.

Other conditions being equal, the difference in the character of the seed coats and coverings, especially in their ability to quickly or tardily absorb moisture, as well as the amount of water necessary to be absorbed, must largely explain the inequalities in time of germination. The thin, easily rotted seed covering of the Maples, Elms, Birches, Ashes, Pines, and Spruces are quickly acted upon by soil moisture, and, if perfectly fresh, the seed may be expected to germinate more promptly than seed with heavier coverings. Most of the locust tree seeds and their allies have thin seed coats, but the substance of the seed is thick, dense, and horny, naturally requiring months, or even several years, of contact with the soil of average humidity before they are sufficiently permeated with moisture to grow. Similar also in the length of time required to germinate are the thick-shelled seeds of the Junipers, Hollies, and Hawthorns.

The germination of such seeds as Persimmon, Juniper, Holly, Hawthorn, etc., will be greatly hastened by placing them in vessels of warm water—at least a bucketful to one or two quarts of seed—and letting them soak for five or six days. The germination of Juniper seed may also be still more hastened by placing the water-soaked seed in lye for two days; lye made from wood ashes should be used. Soaked seed should be planted at once. The seeds of Acacias, Locusts, Kentucky Coffeetree, Redbuds, and Yellow-wood should be treated as follows before planting: Place the seed in a vessel of water heated to the boiling point and stir briskly at intervals during five to ten minutes; then leave the seeds to soak for three to four days. At the end of this time take out the seeds which are floating on the surface of the water and plant them at once in moist earth, being careful not to allow them to dry out. They will be in excellent condition and should germinate promptly. Continue scalding the sunken seeds till all have risen, promptly sowing, as before, the supply secured from each treatment. The different degrees of dryness common to seed of this class accounts for the difference in the amount of soaking required for each lot.

The seed kernels of the nut-bearing trees, and of Oaks, Junipers, and Hawthorns are unable to burst through the hard, strong shells surrounding them until the latter are thoroughly saturated with moisture and partly decayed, a process requiring, according to the character of the covering and the amount of moisture in the soil, from half of one season to two or three seasons.

PROPAGATION OF TREES FROM SEEDS AND CUTTINGS.

PROPAGATING FROM SEEDS.

Propagation of tree seeds is similar to that of garden seeds.

But little can be said concerning the sowing of tree seeds which does not apply as well to ordinary garden seeds. There is practically no difference in the care and soil necessary for the best results from either class of seeds. Given a moderately rich, gravelly or sandy, porous, moist soil, within the proper range of temperature, any tree can be propagated from the seed and made to live for a longer or shorter time.

NATURAL SEEDING.

Natural seeding is uncertain, except in loose, constantly moist soils, protected from grazing and fire.

One of the important considerations in raising tree seedlings is to produce the largest amount of good stock with the least expenditure of money, time, and labor. Nature's method of sowing seeds broadcast is too often uncertain, because the necessary conditions for germination are perfect only by chance. The Ash, Walnut, Hickory, Oak, and other trees which bear an abundance of seed in pastures or other fields are rarely surrounded by a thicket of young trees. The conditions favorable to the preservation and germination of seed on such sites are usually wanting when the seed is shed, so that it is either all destroyed or never germinates, or, if it does sprout, the tender seedlings die from exposure to wind, sun, or the trampling of stock. On the other hand, if a sufficiently soft, penetrable, and moist soil be at hand, such as may occur in a forest protected from grazing and fire, nature's sowings do well, and a multitude of Maples, Ashes, Birches, Pines, etc., cover the ground beneath or near the seed trees.

If managed by an expert forester natural seeding of cleared land from adjacent forests may often be depended on for recovering such areas with useful timber trees. Where opportunities for this kind of reproduction are favorable, natural seeding may with advantage be resorted to by the farmer also. Thus in naturally wooded hilly regions of the East protective forest covers can be cheaply and surely returned to steep unproductive slopes by natural seeding from adjoining woodland. Valuable agricultural lands at the bottom of such slopes are then protected from further dangerous washing.

But where the farmer has the definite purpose of producing useful timber without loss of time, natural seeding is not to be depended on. Direct planting of sufficiently advanced nursery stock has the advantage over natural seeding of establishing more quickly and with greater certainty only such timber trees as are wanted.

PLANTING AND SOWING SEED WITH FIELD CROPS OR ON PREPARED AND UNPREPARED GROUND.

Planting seed with cultivated crops, or sowing broadcast on prepared and unprepared land, is uncertain, giving less uniform results than planting nursery grown seedlings.

The planting of the seeds in hills or rows alternating with some hoed or cultivated field crop, or sowing broadcast with a grain crop[1] (oats, buckwheat, etc.), has been tried to some extent in the prairie region, but usually with poor results, especially with the broadcast sowing. Walnuts, Osage Orange, Green Ash, and Catalpa have succeeded fairly well when planted in alternating rows with corn and subsequently cultivated for several years.

Another similar method is to prepare the ground as thoroughly as possible by plowing and harrowing either the whole or alternating parallel strips from 1 to 6 furrows wide. The seed is then sown broadcast on the prepared land, which is harrowed to cover the seed. Stock is kept out and the sowing left to take care of itself. The seedlings are compelled to fight for a standing with weeds, grass, and all other comers. The growth of the seedlings is usually slow; many of them die in the struggle and many seeds fail to germinate.

Seed may also be sowed broadcast on unprepared land in early spring before or after the snow goes off. Sowing on bare unprepared land gives very few seedlings or, more otten, entire failure, but sowing seed on snow in early spring gives much better results. Seed moistened by the melting snow is likely to germinate whenever by accident it comes into close contact with the soil, while the seed sowed directly on the ground usually fails to germinate for lack of timely and sufficient moisture.

But for the establishment of large, or even small, forest plantations, the above methods of sowing with or without crops, or planting the seeds in hills, have little to commend them over the more economical and surer method of establishing a plantation by raising seedlings in a seed bed and nursery and afterwards transplanting them to their permanent site.

---

[1] In parts of France, Germany, and Russia cleared strips of government forest land are sometimes turned over to peasants for cultivation with the provision that during the last year of tenure tree seeds shall be sown with the field crop.

SEED-BED CULTURE.

Seed-bed culture requires the least labor and produces the most and best stock.

A large stock of tree seedlings can be raised in seed beds at a comparatively small cost. The perfect soil preparation necessary to the fullest germination of seed and the vigorous growth of the seedlings is easily secured on the limited area of a seed bed, whereas similar preparations for sowing seed in a large field, where the trees are to stand permanently, would require much more labor and would probably be less perfect in result. Moreover, the seedlings are thus brought through their most tender age in the seed bed, where they can receive better cultivation and protection from sun and drought.

LOCATION, SOIL, PREPARATION, AND SIZE OF THE SEED BED.

Locate the seed bed on a well-drained site. The preferable soil is a deep, sandy loam; loose gravelly soil is next best. Enrich poor soils. Plow or spade deep, and harrow or rake thoroughly.

Location of seed bed.—A site on high ground affording good surface drainage without severe washing is most suitable for a seed bed. Where possible, level ground should be chosen in place of slopes where there is likely to be too much surface washing. When necessary to locate on a slope, the gentlest one should be preferred. A portion of a well-worked field or garden is better than new ground or that long out of use.

Whether the beds should be located near the home site or near the proposed forest plantation is a question to be carefully considered from the standpoint of economy in time in reaching the beds for cultivation and for convenient access to water. Proximity to the site of the forest plantation will be advantageous for quickly transferring the seedlings by hand to the ground where the final planting is to be done. There may, however, be no convenient water supply which, in case of drought, is indispensable for the beds after the seed is sown or for the growing plants. If far from the home site, much time must also be consumed in going and coming from the beds during the period of cultivation and other attention. All points considered, it will probably be most advantageous for the average farmer to locate seed beds near home.

Where possible, seed beds are best located on the east or, preferably, on the north side of a hedge, wind-break, building, or fence for the sake of extra shelter from the sun. Seed beds may be located in open places in a forest, or outside, near an eastern or northern border. The establishment of seed beds and nurseries in and very near forests is the prevailing practice of European foresters, one of the main objects being to have the plant material near the sites of the plantations.

Soil and preparation.—Preferably the soil should be a deep, sandy loam of moderate richness. A deep, loose, gravelly soil will be favorable if the finer soil can not be had. If the soil is naturally poor it should be enriched with well-rotted manure. If the ground has been under continuous cultivation, a deep plowing or spading and thorough raking or harrowing will suffice for preparation. If the ground has been long uncultivated—pasture, meadow, or waste ground—it will be of the greatest advantage to plow or spade the site 10 to 12 inches deep the fall before the intended planting, if possible, turning under 4 to 6 inches of rotted manure. As soon as the ground can be worked in the spring it should be plowed or spaded again and thoroughly pulverized by raking or harrowing, removing all clods, stones, etc.

If this preparation seems too painstaking, it need only be said that crops are good in proportion to the amount of good tillage they receive before and after planting. No one knows this better than the successful farmer. The extra preparation of the seed bed will be amply repaid by more and better seedlings.

Size of the seed bed.—The size of the seed bed will, of course, be determined by the amount of seed to be sown. A convenient width is four feet, the length varying up to several hundred feet, or more, according to the space required. The width is important, because it determines convenience in sowing and weeding and in the use of portable screens (see p. 46). Otherwise the bed can be formed much the same as the ordinary garden bed. For large numbers of certain vigorous growing seedlings (mentioned on p. 42), it will usually be advisable to abandon this special form of seed bed, and to sow the seeds in long rows, far enough apart to allow cultivating with a horse. If hoed, long rows will also be preferable to the shorter ones.

BOX CULTURE.

An advantageous culture for a small number of seedlings and for early indoor sowings; box culture also stimulates large root growth, which is favorable to transplanting.

A modification of the seed bed is the use of shallow boxes filled with earth in which the seeds are sown. For small quantities of seeds this system has some advantages over the ordinary seed bed; principal among them is that sowing can be commenced much sooner, if desirable, as the boxes (being of convenient size) can be kept indoors during early spring, and when the weather is warm enough they can be arranged out of doors. Boxes are also of advantage in better fitting a few kinds, such as the Oaks and Hickories, to stand transplanting. If planted in the open ground, such seedlings produce large, long tap roots with few secondary roots. The effect of growing them in shallow boxes is, by refusing the roots depth, to stimulate a greater development of lateral roots. Seedlings so prepared rarely fail when transplanted.

SOWING THE SEED.

There are two methods of sowing seeds, (1) broadcast and (2) in rows; the latter is preferable as it gives stronger plants and avoids much hand weeding. Broadcast sowing gives more seedlings per foot, but the plants are weaker unless thinned, and require much hand weeding.

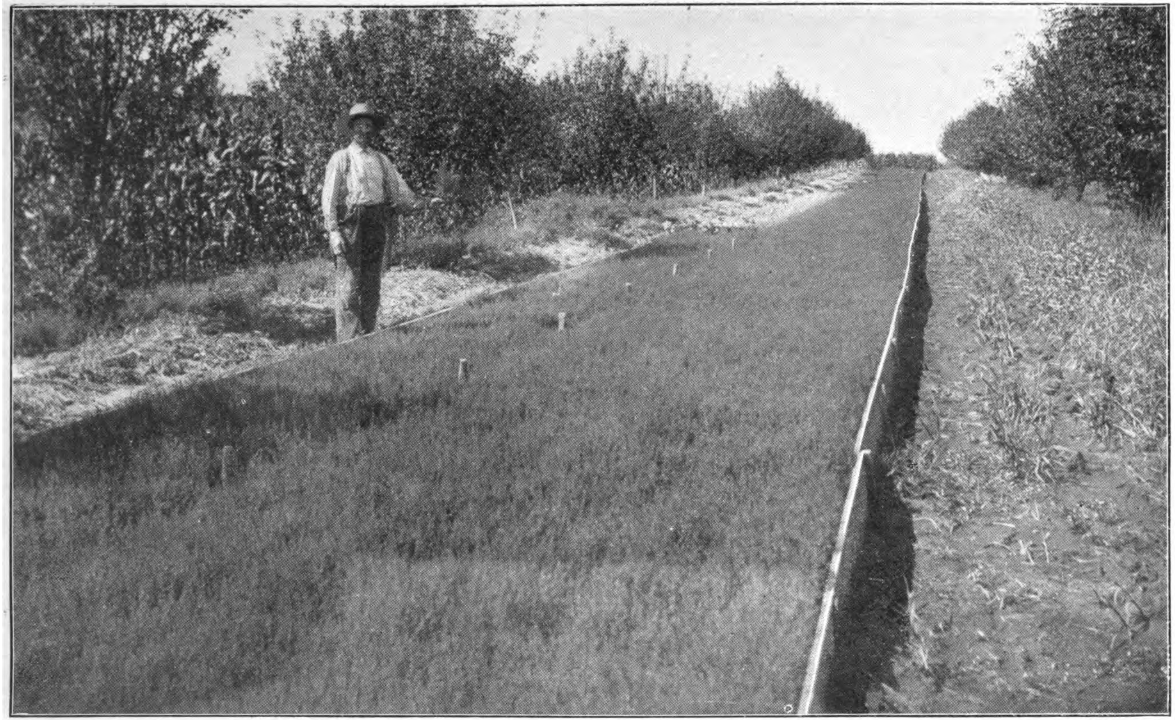
Comparison of broadcast and drill sowing.—A proportionately larger number of seedlings can be raised by sowing broadcast than in rows, and for this reason most nurserymen adopt the former method. (See Pl. IV.) Sowing in rows is preferable, however, to broadcast sowing, for the reason that most of the weeding can then be done with a hoe or other weeding tool, while the weeding when sown broadcast must be done entirely by hand.

It should be remarked that it is sometimes possible to secure so dense a stand of seedlings by broadcast sowing that many weeds will be choked or shaded out, but in general practice such conditions are difficult to establish except with thickly sown seeds of uniformly high rates of germination. The failure of certain seeds to germinate must cause openings in the bed and, therefore, opportunities for the weeds to come in. Moreover, a careful study of many seed-bed plants from broadcast sowing shows that there is a great difference between size and vigor of plants on the margins and of those in and near the center of the beds; the latter are usually slender and weak, while those on the borders are robust and strong. Seeds sown in rows produce plants of uniform size and vigor throughout the beds.

SOWING IN DRILLS OR ROWS.

Sow seed of conifers, Birches, Cherries, Elms, hard Maples, Ashes, Hackberry, etc., in rows 8 to 12 inches apart for hand cultivating; sow nuts, acorns, and seed of soft Maples, Catalpas, Locusts, etc., in plain rows 3½ feet apart for horse cultivating, or 2 feet apart for hand cultivating.

It is recommended that all seeds be sown in rows, both to facilitate weeding and also to give an opportunity easily to cultivate the soil about the plants. The latter is especially advantageous to plants in dry weather, preventing rapid evaporation from the soil. The seeds which produce comparatively small seedlings the first year, such as conifers, Birch, Cherry, Elm, hard Maple, and Hackberry, can be sown in small beds, similar to those for garden plants, and in rows 8 to 12 inches apart. The bulkier and more rapid-growing seedlings of soft Maples, Hickories, Walnuts, Catalpas, Oaks, and Locusts, except for very small quantities (when a small bed will answer), must have more space between the rows. The form of the seed bed may then have no likeness to the ordinary raised garden bed, but will be in the nature of a nursery plat, in which the seed is sown in rows 3 to 3½ feet apart, so as to allow the easy passage of a small horse cultivator, or 2 feet apart if cultivated by hand.



ROCKY MOUNTAIN JUNIPER SEEDLINGS, 2 YEARS OLD, 8 TO 18 INCHES HIGH. ONE-EIGHTH OF AN ACRE OF SEED BED, CONTAINING 1,000,000 PLANTS, AND SHOWING AN EXCEPTIONALLY DENSE STAND FROM BROADCAST SOWING.

[Propagated by W. H. Bruning, Cedarbluffs, Nebr.]

It is important to impress upon the planter at this juncture that all seeds stored for the winter in earth or sand should be sown at once after they are uncovered, or so protected till sown that they will not be dried out in the least. The partial drying out of such moist seed may be fatal to its vitality. Seed kept for the winter in dry, cool storage is also better for being promptly sown after it is removed from its storage.

Thick and thin sowing.—The proper spacing of seed in the row is important in economy of seed and in the production, from the first, of the most vigorous plants. If seed of a high rate of germination is carelessly and thickly sown, the result is a much too crowded stand of seedlings, which must be thinned out at an early age to prevent a weakened growth. The plants taken out can rarely be saved by transplanting them, and will, therefore, be wasted. In the case of expensive conifer seeds, it is especially urgent that the sowing be done economically.

In practice it is very difficult and slow work to sow tree seeds so that the seedlings will not require thinning. This is especially true of such light seeds as those of Arborvitæs, Incense Cedar, Cypresses, Elms, Birches, Catalpas, and the smaller Pine, Spruce, Fir, Hemlock, and Larch seeds from which the wings have not been removed. The winged seeds of Ashes, Maples, and Tulip-tree are also troublesome. Above all, high winds will often try the sower's patience by blowing the seeds about, and at times prevent him from sowing light seeds, except with great waste. The heavier, grain-like seeds, nuts, and acorns will be more easily managed.

Spacing seeds in the row.—Excepting the nuts and acorns, seeds with a maximum vitality of over 50 per cent in the table on p. 36 should be spaced at about 1 to 1½ inches in the row, while seeds with a maximum percentage of germination lower than 50 may be strewn so that the grains either touch each other or are spaced from about one-fourth to one-half an inch. Seed of the Tulip-tree, which has a very low per cent of germination, should be sown thickly—three or four seeds deep—in order to secure a well-spaced stand of seedlings.

The breadth of the drill or seed row may vary from a single line of plants to a row 1 inch broad. Hickory nuts, walnuts, acorns, chestnuts, and beechnuts may be planted from 2 to 4 inches apart in a single line. Nurserymen frequently make seed rows from 2 to 6 inches wide, thus greatly increasing the number of plants raised per row. It is believed, however, that the narrower seed row will be more satisfactory for home practice.

Table showing the number of tree seeds per ounce and pound, and also the approximate number of linear feet of seed drill covered by each quantity.

Name of species.	Number of seeds in 1 ounce.	Number of seeds in 1 pound.	Approximate number of linear feet of seed-drill covered by 1 ounce.	Approximate number of linear feet of seed drill covered by 1 pound.
White Pine	1,800	28,800	36	576
Red Pine	4,760	76,160	75	1,200
Shortleaf Pine	4,990	79,840	80	1,280
Bull Pine	100	1,600	16	256
Scotch Pine	2,430	38,880	60	960
Norway Spruce	5,260	84,160	75	1,200
Red Fir	4,200	67,200	60	960
White Fir	610	9,760	10	160
Bald Cypress[1]	320	5,120	20	320
Red Juniper	1,310	20,960	40	640
Incense Cedar	1,260	20,160	35	560
Lawson Cypress	6,400	102,400	40	640
Butternut	1 (+)	16	....	4
Black Walnut	2 (−)	30	....	8
Shellbark Hickory	5	80	....	14
Chestnut	6	98	....	17
Black Locust	1,810	28,960	60	960
Honey Locust	200	3,200	16	256
Hardy Catalpa	1,230	19,680	60	960
Osage Orange	820	13,120	30	480
Green Ash	1,020	16,320	25	400
White Ash	640	10,200	25	400
Black Ash	380	6,100	18	288
Boxelder	920	14,720	26	416
Sugar Maple	470	7,498	20	320
Scarlet Maple	140	21,980	50	800
Black Cherry	279	4,464	20	320
Basswood	397	6,352	15	240
American Elm	5,820	93,120	125	2,000
Slippery Elm	3,398	54,368	80	1,280
Birch[2]	30,116	481,856	750	12,000

[1] About 50 per cent of the bulk of Cypress seed in the trade consists of refuse shells of cones.
[2] Includes principal Eastern species.

Marking seed rows.—For smaller seeds the preparing of seed drills in which to sow tree seeds is not different from that practiced in sowing ordinary garden seeds in drilled beds. Parallel drills can be made by running a stick or hoe handle along the straight edge of a board long enough to span the bed. The sowing and covering of the seed is then done by walking on the board to avoid trampling the soil. Longer seed rows and those for nuts and acorns can be marked with a stick or pointed hoe along a garden line; or the ground can be marked off in parallel rows with a temporary marker like those used for marking corn ground. The track of the marker will usually form a drill deep enough to receive the seed.

WHEN TO SOW.

Sow seed from April to middle of May, when the soil is moderately moist, not when wet nor very dry.

The time to sow seeds will vary with the region. In general this is as soon in the spring as the soil is dry enough to be worked. For the northern and middle United States this will be from the 1st of April to about the 20th of May. For the southern States sowing may be done in February and March. Seeds are best sown when the soil is moist, never when wet or entirely dry. If the soil is wet and remains so, the seeds are liable to rot before they germinate; and if very dry they are likely to lose much time in late germination or to "lie over" till another season.

COVERING SEEDS IN THE SEED BED.

Cover small seeds two or three times their own depth; cover large seeds about twice their depth. Firm the earth over the seed rows by rolling, pressing down with a board, or patting with the back of a hoe or spade.

The proper covering of seeds when sowed is an important consideration. If the cover is too shallow the seeds may be washed out, and if too deep they may rot, or the plants may not push through the heavy cover, or the seeds may even lie buried in a living half-germinated state till another season.[1]

A safe rule for covering all small seeds is at least twice and not more than three times their own depth; large seeds may be covered about twice their depth. Seeds will germinate much better and are less likely to be washed out if after sowing the soil be firmed by running a light roller over the entire bed, or if the earth over the seed row be gently tapped with the back of a hoe or pressed with a board.

MOISTURE IN SEED BEDS.

The soil should contain enough moisture to give an even freshness. For conserving this moisture place a 2-inch cover of chaff or straw over the bed until the seedlings begin to appear, when the covering should be removed.

An even supply of moisture in the soil gives the highest rate of germination for all seeds and in the shortest time. The proper amount of moisture is also of equal importance. Damage will as often be done by too much water as by allowing the soil to become dry and baked; the essential point is to maintain enough moisture in the soil to give freshness and looseness. A sprinkling of 1 to 2 inches of dry wheat chaff over the seed bed will hold the natural moisture of the soil for a long time. If watering becomes necessary, the covering will prevent undue packing and washing of the soil by allowing the water to percolate into the soil gradually.

A close watch should be kept upon the beds, and as soon as the seedlings begin to break through the ground the covering must be removed.

---

[1] The writer has seen Black Walnuts planted at a depth of 6 to 12 inches germinating the second season. It is possible for many other kinds of seeds, when buried at a depth of 6 inches to several feet, to retain their vitality for from one to ten or more years.

SHADING SEEDLINGS.

Shade conifer seedlings during the first two seasons and broadleaf seedlings during the first season.

General remarks.—Many broadleaf seedlings, such as Catalpas, Locusts, Ashes, Boxelder, Maples, etc., will endure exposure to the hot sun during their tender early growth, but almost all tree seedlings are better with a light protection until they have become hardened. A few of the conifers also endure early exposure, yet shade is very beneficial to these plants during the first season; in fact, for some of the tender kinds shade is absolutely necessary for success.

Making screens.—Shade may be variously and cheaply supplied by lath screens the size of the whole bed, or preferably by several screens of such convenient size that combined they will cover the bed. Screens are made by nailing lath of full length on two end rails (1 to 2 inches thick and 4 to 5 feet long), spacing the lath about 1½ inches. For shading the beds, the screens should be supported 18 to 24 inches above the ground; 18 inches is high enough for all conifers and 24 inches is about right for all other seedlings.

This is done by driving a line of small posts into the ground on the two long sides of the bed, the distance from post to post across the bed being right to catch the ends of a screen. These posts are placed at intervals of 4 to 5 feet apart in the line, and, according to the class of plants to be shaded, the tops of the posts are left at a height of 18 to 24 inches above ground. Slats (1 to 2 inches wide) then may be nailed along the tops of each line of posts to form a convenient support for the screens, which are laid side by side, resting their ends on these slats; but preferably each screen may be simply rested on four corner posts. This will give free access to the beds for cultivation.

Slat screens may also be made by weaving lath together, at the proper distance apart, with three to four strands of small fence or baling wire, in the same manner as in making a slat-and-wire fence. Two anchor posts are used for this weaving. The long strips of screen woven can be cut into convenient short lengths, or used of any length sufficient to cover one long bed. Long screens are put on or taken off the beds by unrolling and rolling the screen.

An effective screen is made by stretching a cheap muslin on convenient-sized frames. This screen affords complete protection with a strong diffused light, but is likely to be troublesome in case of high winds, when the slat screen is preferable.

The practice of nurserymen is not uniform in the height at which screens are supported above the seed bed. Some place the screens at from 1 to 2 feet above the bed, while others hold that a height of 4 to 5 feet is preferable. The use of high screens permits cultivation of the beds without removing the screens, and also gives a somewhat freer circulation of air over the beds than the low screens. The latter have to be taken off when the beds are cultivated. Another advantage of the high screen over the low one is that often the former may be very inexpensively constructed by laying leafy branches or brush over supporting poles. Such a screen need not be disturbed during cultivation, while a low screen so constructed could not be handily removed to permit cultivation.

Beds covered with high-roofed screens will need screening on the eastern, southern, and western sides, in order to protect the outside plants from being scorched. Side protection also of seed beds covered with low screens will be advantageous for Western regions, especially on sides toward the prevailing hot winds. Otherwise severe and rapid drying out of the seed bed may take place.

In conclusion it may be said that seedlings are grown with equal success under both the high and low form of screen, so that the planter may choose either.

How long seedlings should be shaded.—For conifers the screens may be advantageously kept over the seed beds from the time the seeds are sowed till the fall of the second season, setting the screens aside only on cloudy days or during gentle rains. In case, however, previous to an expected rain, the soil is already sufficiently moist (and very close attention should be given to this point), the screens may be left on as a partial protection against excessive wetting of the soil. For this purpose one side of the screens should be raised so as to allow the water to run off quickly. If much rain falls during the first four to six weeks after the seedlings are up, a temporary but tight cover of boards should be placed over the beds in order to positively prevent any further wetting of the soil, for if continuous heavy rains are allowed to soak the beds, interspersed or followed by several hot or even warm days, very destructive "damping off"[1] is almost sure to follow. Rapid surface drainage should be arranged to carry water away from the beds as it runs from the covers.

Most broadleaf seedlings will not require continuous shading after the first two or possibly three months, for they are little affected by the sun after their second leaves have appeared. Following this period, if the weather is moderate, the seedlings can be "hardened off" for several days by leaving them unprotected, except during the hottest part of the day, or during protracted hot, dry weather, when they should be shaded.

With seed beds located on the north side of a high building or screen of shade trees, it is possible to raise broadleaf seedlings without screens at all. Conifer seedlings can also be successfully raised without screens by making the beds in the shade of a grove of trees.

---

[1] See page 49.

WATERING SEEDLINGS.

Keep the soil evenly moist to a depth of at least 6 inches. Apply water to the beds gently and let it soak into the soil slowly and deeply.

The necessity of an even supply of moisture in the seed bed before the seeds have germinated has already been pointed out. The same is true after germination, conifers, as a rule, requiring less water than broadleaf kinds. If rain does not furnish enough moisture, the beds should be watered once or twice a week, and sufficiently to saturate the earth at least half a foot down. A mere sprinkling of the surface during very dry weather will avail nothing. Watering should not be done spasmodically, but promptly whenever the soil moisture begins to fail, for the growth of seedlings will be checked and injured by alternate wetting and drying. Early morning or toward sundown is a good time to water.

A good way to apply water is in shallow runways between the rows of seedlings, connecting the runways with each other at the ends of the rows, so that the water poured or allowed to run in gently may stand between rows and soak down. The bed will thus be saturated without compacting the soil. The facilities of the planter for applying water to seed beds will of course vary. Most farmers in the East will have to carry, haul, or conduct water from a well, cistern, pond, or stream, while farmers in the West may more easily supply water to seed beds from reservoirs or irrigation ditches. As previously advised, it will be well to locate the seed beds and nursery as near as possible to the water supply.

CULTIVATION OF SEEDLINGS IN THE SEED BED.

Cultivate often to subdue weeds, stimulate growth, and prevent evaporation of soil moisture.

Weeds should be promptly removed from the seed bed, for by neglecting to do this the vigor of seedlings may be greatly impaired. As soon as the seedlings are well up the soil should be gently cultivated between the rows. This will stimulate the growth of the plants and check rapid evaporation of soil moisture. For small beds cultivating can be done with a hoe or similar tool, while for the more extensive sowings in wider rows it can be conveniently done by a horse with some form of small cultivator. Frequent working among the seedlings should be continued throughout the summer and will be profitable if done oftener than is necessary to keep down the weeds. This is especially true if the weather is hot and dry.

The following table furnishes information as to the rate of growth for the first year of several species of trees under cultivation:

Approximate height of 1-year-old seedlings in cultivation.

Name of species.	Approximate height in inches.	Name of species.	Approximate height in inches.
White Pine	2½ to 3½	White Ash	6 to 10+
Red Pine	2 3	Green Ash	6 10+
Bull Pine	2½ 4	Red Ash	6 10+
Scotch Pine	2 4	Black Ash	6 10+
Banksian Pine	2½ 3½	Blue Ash	6 10+
Tamarack	2 3	Black Walnut	10 14
White Spruce	1½ 2½	Butternut	10 14
Black Spruce	1½ 2½	Shellbark Hickory	6 9
Red Spruce	1½ 2½	Mockernut Hickory	6 9
Blue Spruce	1½ 3	Pignut Hickory	6 9
Engelmann Spruce	2 3½	American Elm	5 10+
Red Fir	3 4½	Cork Elm	5 10+
Hemlock	2 3½	Winged Elm	5 10+
Western Hemlock	2 3½	Slippery Elm	10 18+
White Fir	1½ 2½	Hackberry	6 12
Arborvitæ	1½ 2½	Red Mulberry	8 10+
Giant Arborvitæ	1½ 2½	Russian Mulberry	8 10+
Incense Cedar	2 3	Black Locust	18 20+
Lawson Cypress	1½ 2½	Honey Locust	6 14
Red Juniper	2 3½	Kentucky Coffeetree	6 12+
White Oak	5 9	Paper Birch	3 8+
Chestnut Oak	5 9	Yellow Birch	3 8+
Post Oak	5 9	Sweet Birch	3 8+
Burr Oak	5 9	Black Cherry	8 14
Cow Oak	5 9	Sugar Maple	6 12+
Red Oak	6 12+	Red Maple	6 10
Black Oak	6 12+	Silver Maple	12 20+
Scarlet Oak	6 12+	Boxelder	10 14
Pin Oak	6 12+	Basswood	6 12
Water Oak	6 12+	Hardy Catalpa	14 20+

"DAMPING OFF."

"Damping off" is a fungous disease destructive to very young seedlings. Avoid it by preventing excessive moisture in seed beds soon after the seedlings come up, especially in hot weather. Prevention is aided also by thin sowing, frequent cultivation, allowing free circulation of air among seedlings, and by sprinkling one-fourth to one-half an inch of dry warm sand over the bed.

The destructive malady known as "damping off" attacks tree seedlings during their early tender growth. It is manifested by a sudden wilting and dying of large numbers of plants without apparent cause. The disease is most prevalent among conifers, but young broadleaf seedlings also are sometimes affected. It is caused by a fungus, the growth of which is promoted by excessive moisture in the soil, accompanied by hot, murky weather. The presence of such conditions during the critical period—usually the first two or three weeks of growth—may result in the wilting and dying of thousands of seedlings in a single day. There is no help for the wilting plants, but those still unaffected may sometimes be saved by drying out the soil in the beds. Allowing free circulation of air by elevating the screens and lifting them entirely when the sun is off and sprinkling dry, warmed soil or sand around the plants will often check the disease. Preventive measures are, however, likely to be more effectual than local treatment, for, when the disease is once started, there are times when no amount of drying will check the destruction.

As preventives against damping off, thin sowing is recommended for conifers, together with special means of protecting the beds from being soaked by heavy rains. Provision for quickly draining the water from around the bed is also very important. It is best during wet and hot murky weather to keep the soil rather dry and to cultivate frequently.

PROPAGATING TREES FROM CUTTINGS.

Grow willows and poplars from cuttings rather than from seed.

Many broadleaf trees can be grown from cuttings made from branches or sprouts. A few conifers also have been grown from cuttings and from the layered branches of trees. A low branch is bent down and a part buried in the ground till it takes root, when it is cut off. But, for the practical purposes of the forest planter, this method of propagating conifers is too slow and uncertain. The growing of poplars and willows from cuttings is thoroughly practical, and will often be a convenient means of propagating these trees, especially when seeds or seedlings are not available.

The seeds of willows and poplars are comparatively difficult to collect and troublesome to handle in sowing, while the cuttings of these trees are easy to manage.

MAKING CUTTINGS.

In general, willow and poplar cuttings can be made from any time after the fall of the leaves to just before spring growth begins. A good time to make them is in February or March. Cuttings from branches or sprouts of willow and poplar of almost any thickness will grow if placed in the ground; but fully matured 1 or 2-year-old parts of branches (one-fourth to one-half an inch in diameter) will give the liveliest cuttings.

A convenient length for cuttings is from 8 to 12 inches. In making them it is preferable to cut the twigs off square with a thin-bladed hatchet, ax, or, better, with hand pruning shears.

For convenience in handling, cuttings may be tied in bundles of 50 to 100 or more, and if, as they are cut, the top ends are placed one way, no sorting will be needed in setting. To prevent the cuttings from drying out, the bundles should be buried in moist sand or earth till wanted for planting. The covering of sand or earth should be at least 1 foot deep to insure keeping the cuttings moist. Freezing will not injure them.

SETTING CUTTINGS.

Cuttings should be set in the spring. The ground selected for them and its preparation may be the same as that for seeds. If a large number of cuttings are to be set, they should be planted 6 inches apart in rows 3½ feet apart, which will give room for a horse cultivator. A small number of cuttings may be set in rows 2 feet apart and hoed. The growth of cuttings is usually vigorous and more space is needed between rows than for most seedlings of the same age.

Cuttings may be set slantwise or upright in the ground, bottom or larger end down, leaving about 2 inches above ground. Cuttings set slantwise allow the earth to settle better and also to be firmed more closely about the cuttings than when set upright. Close packing of the earth is very important, and for this reason setting the cuttings slantwise is preferable.

To facilitate the planting, a trench may be dug or plowed out in which to set the cuttings. The cuttings are stuck upright in the bottom of the trench, or, if to be set slantwise, laid down along one side, filling in and tamping the earth firmly about them in the manner of planting a tree. Cuttings may also be set in a narrow deep slit made by sinking a spade into the soil, slantwise or vertically, and simply prying the earth apart two or three inches. After putting the cuttings in place, loose earth can be hoed into the slit and firmed about the cuttings by the foot or tamping block. Usually the slit can be properly closed by tamping each side with the foot or block.

Cuttings may also be quickly and successfully planted by simply pushing them into the soil to the proper depth and afterwards tamping the earth firmly about each cutting.

The care and cultivation of cuttings should be the same as for seedlings.

While the preceding remarks apply to cuttings in general, those of the Willows, Poplars, and Artemisias may be set at once in their permanent sites, for their growth is so vigorous as to make them very bulky to transplant if allowed to take root and stand one year in the nursery.

WINTERING AND TRANSPLANTING SEEDLINGS.

WINTERING SEED-BED STOCK.

Protect seed bed before the ground freezes by banking the rows with earth and covering with 3 inches of straw for warm climates and a foot or more for cold climates.

Some protection is necessary, or at least beneficial, in wintering seedlings in their first season. Such preparations should be made just before the ground freezes, or, for mild climates, at the beginning of cold weather.

In regions where the winters are mild and the ground is only slightly frozen, very little winter protection is needed for the seed bed. For broadleaf kinds, a slight "hilling up" of the earth against the row of seedlings to a depth of not over 6 inches will suffice. The trenches thus made between the rows should be shaped so as to carry off all surface water. For conifers, the hilling should just reach the foliage.

Two or 3 inches of straw may be sprinkled over the beds, with branches laid on top to prevent the straw from being blown off. The straw will prevent sun scorching, which is likely to occur toward spring.

Where the winters are severe the seedlings should have, in addition to the banking of the earth, a foot of straw spread over the top and held down by branches or poles.

Chaff, leaves, or moss can be used for protection in place of straw, but the latter is preferable, because it can be much more easily removed in the spring.

TRANSPLANTING SEED-BED STOCK TO THE NURSERY.

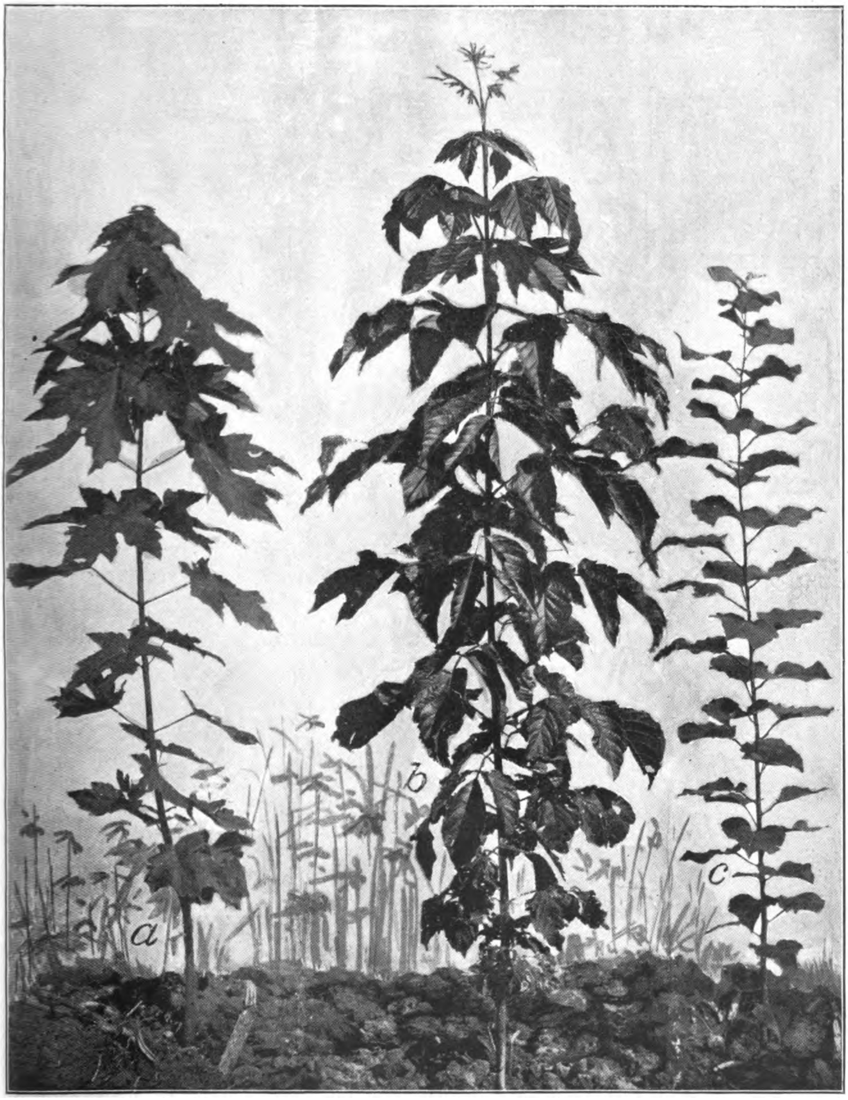
Transplanting increases root growth and thus produces vigorous plants. Transfer such fast-growing 1-year-old stock as Walnuts, Catalpas, Locusts, soft Maples, to nursery rows for a year. Slower growing broadleaf trees and conifers may remain in the seed bed two seasons; then transplant to the nursery for one year, or transplant from the seed bed at 1 year old and grow in the nursery for two seasons.

GENERAL CONSIDERATIONS.

Vigorous root development is produced by transplanting yearling seedlings from the seed bed to nursery rows. The disturbance of the roots in shifting the plants from one site to another, and also the allowance of more room in the nursery, stimulates the growth of small roots. Such plants are markedly more vigorous than those of the same age not transplanted, and therefore establish themselves better when permanently set out. Seedlings taken from the forest are also much improved in vigor by transplanting in the nursery for one or two years.

Instead of transplanting all the plants in a seed bed some nurserymen take out only a part of them. Those left in the seed bed are thus given room enough to grow freely till sufficiently large for permanent planting. This method of thinning is applied with some advantage to beds with large numbers of seedlings in dense stand. The saving lies in reducing the cost of transplanting all the seed-bed stock, but the stimulated root growth which follows transplanting is lost to the plants left in the seed bed, which are thus inferior to seedlings transplanted once or twice.

The slow or rapid growth of various kinds of seedlings during the first two or three years may determine the length of time seedlings should stand in the seed bed, as well as that necessary for nursery training. The slow growth of conifers makes it possible to leave them in the seed bed two years, afterwards transplanting them to the nursery for one or more seasons. If 1-year-old conifers are transplanted from the seed bed it is advisable to give them about two years in the nursery (see figs. 2 and 8). As a rule, broadleaf seedlings grow much more rapidly and need less time in the nursery. Walnuts, soft



SEEDLINGS: *a*, SILVER MAPLE SEEDLING, 2 YEARS OLD, 36 INCHES HIGH, IN PERMANENT PLANTATION, NEBRASKA; *b*, BOXELDER SEEDLING, 2 YEARS OLD, 36 INCHES HIGH, IN PERMANENT PLANTATION, COLORADO; *c*, ASPEN SEEDLING, 2 YEARS OLD, 35 INCHES HIGH, IN PERMANENT PLANTATION, UTAH.

Maples, Catalpas, Locusts, Coffeetree, and others, may attain sufficient size and vigor to be fit for final planting even at the end of the first season in the seed bed (especially if they have had plenty of room and frequent cultivation), but they are better for one year in the nursery. (See Pl. V.) Among the broadleaf species which usually grow more slowly for the first season are the Birches, hard Maples, Ashes, Cherries, Hackberries, Oaks, native Mulberries, and Elms, and they should therefore remain in the nursery for one or two seasons before final planting.

It should be added that the growth of seedlings of the same kind in different soils is so variable that it is difficult to state the exact amount of nursery treatment required to fit all seedlings for final planting. Thus in a poor soil an ash seedling may be none too far advanced after two years in the nursery, while in a richer, freer, and moister soil one year in the nursery may suffice. As a rule, however, it is advisable to give the rapid-growing, broadleaf kinds one year and the slower ones two years in the nursery rows.

ROOT PRUNING.

Judicious pruning stimulates the growth of side roots and gives vigor to the plant. Seedling Oaks, Walnuts, and Catalpas form long, fleshy taproots during the first season with but few lateral roots. This form of root is very troublesome to plant. Before setting such plants in the nursery from one-fourth to one-third of the root should be clipped off. Any other long, straggling roots of seedlings are best cut off. Seedlings with a bunch of short, fibrous roots need no cutting.

One-year-old cuttings have no taproots, but very long side roots will need shortening.

FALL AND SPRING TRANSPLANTING.

Fall transplanting is desirable only for warm regions; spring transplanting is best for cold climates.

Both fall and spring planting have their adherents. Each method is successful in the hands of professionals. The amount of time available, however, for such work in spring or fall may partly decide the adoption of one or the other method. The region will also have an important bearing. For example, in climates where the fall season is long, mild, and gradually merges into winter fall transplanting may be safely attempted. The young trees will make considerable root growth before winter, and thus gain an earlier start in the spring. But in regions where the fall season is short, cold, and abrupt fall transplanting would be hazardous and uncertain. The lack of sufficient fall root growth, coupled with the danger of "heaving," is likely to give bad results. The seedlings are much safer properly protected in the seed bed.

Many failures in fall transplanting are, however, due largely to setting the trees too late—often just before the ground is frozen or when it is wet and cold.

The planter is recommended to transplant in the fall wherever the region is favorable. Otherwise spring planting will be more desirable.

FALL TRANSPLANTING.

Fall transplanting can be done as soon as the summer's growth is over, a time which is indicated for broadleaf trees by the change of color and shriveling or falling of the leaves. The right time for transplanting coniferous plants will be indicated by the presence of a perfectly formed winter bud at the end of the season's growth.

Fall and spring transplanting are not different, so that the directions further on for spring transplanting will serve also for fall.

TAKING UP SEEDLINGS.

Success in handling seedlings depends largely upon the care with which they are taken up. The seedlings taken up with the least injury will recover most readily after setting. The preferable method is gently to raise several seedlings by sinking a spade deep into the soil 5 or 6 inches to one side of the plants and then prying up. They can then be gently pulled out and freed from the loosened earth. A much less desirable method is to pull a handful of seedlings at a time without loosening the earth. If the soil is very loose, a careful operator can lift the plants without very much injury to the roots; but if the soil is hard, great injury follows. Seedlings are pulled in this manner by grasping a bunch of stems close to the ground, and giving a steady, gentle pull till the bunch is lifted.

TRANSPORTING STOCK FROM SEED BED TO NURSERY.

After seed-bed stock has been taken up, it must usually be transported some distance for planting in the nursery or plantation. It is very important that this be done with care. Uprooted seedlings of all kinds suffer more or less when exposed to wind and sun. Conifers may be ruined by a few moments' exposure, while such seedlings as Poplars, Willows, and Mulberries may endure several days of drying and recover when planted. It is best, however, to give them all protection against drying out, thus saving even the hardiest kinds an unnecessary shock.

As the seedlings are being dug or pulled they should be laid, roots together, in separate piles of one to several hundred, or in one long pile, and the roots immediately covered to keep them perfectly moist. This can be done with a wet blanket, or with carpet, burlap, or bags, but a few shovelfuls of fresh earth is an excellent protection and is easily applied. From 6 to 10 inches should be put on the roots to prevent drying out.

Equal care should be taken to have the newly lifted stock thoroughly covered when transporting it to the nursery. If the seedlings are to be carried only a short distance, they are best packed, root ends together, lying on their sides on a layer of wet straw, chaff, cloth, or earth, in boxes, or in a tight wagon box. A cover of wet chaff, straw, cloth, etc., should then be thrown over all during transit. If the seedlings are to be hauled or shipped some distance by rail, they can be similarly packed in boxes, placing wet moss at the roots between every 6-inch layer of plants. The root ends should be tightly packed, pressed down, and held there by nailing inch-thick slats (3 to 6 inches wide) across the roots of each tier of plants; the slats may be securely held down by cleats nailed above each end to the inside of the box. The top of the box should be loosely slatted to give air.

The ingenuity of the planter will suggest other simple and effective methods of packing. The essential requirements of all packing are to hold the roots firmly together in wet moss to preserve their freshness, and to prevent bruising or other injury to the tops.

SPRING TRANSPLANTING.

As soon as the soil is dry enough to be worked, a piece of ground should be prepared for a nursery. The same situation, soil, and preparation are necessary as for seed beds. When prepared the ground is marked off in parallel rows one way. For hand cultivation, the rows containing conifers should be 1 foot apart, and for broadleaf trees 2 feet apart. For cultivating with a horse, the width of rows may be 3½ to 4 feet. When the plants are ready to set, trenches are hoed, dug, or plowed out, corresponding with the rows marked off, in which to set the seedlings. The trenches should be from 6 to 10 inches deep, according to the size of the plants. The planter must decide this, keeping in mind the general fact that the plants are to be set 1 to 2 inches deeper than they grew. In poor shallow soils the richer top earth should be kept separate for filling in about the roots; in deep rich soil this precaution will be unnecessary.

In case the soil is very dry to the depth of the trenches prepared, it will be of great advantage to water the trenches before setting the plants.

Conifer seedlings one to two years old may be set 4 inches apart in the row, and broadleaf plants of the same age about 6 inches apart.

If, in taking up and carrying the seedlings from the seed bed to the nursery, the roots have been kept moist, the plants may be set at once without further preparation. To insure having the roots perfectly moist when planted, however, which is most essential to successful transplanting, the seedling roots should be dipped in a mud bath.

The latter is prepared as follows: Make three-fourths of a bucketful of thinnish puddle by mixing water and earth—light, loamy earth or muck is preferable. Stir the puddle thoroughly and plunge as large a bunch of seedling roots down into the mixture as the bucket will accommodate. Souse the bunch several times to coat thoroughly all the roots. The seedlings are now ready for transplanting. The bucket is a convenient means of carrying the plants along the nursery row where, one by one, they are dropped in place.

Having previously marked and prepared the nursery-row trenches, as already described, the transplanting may proceed as below. Speed in all the steps is of the greatest importance to success. A clean-cut plan must be followed throughout, with no delay whatever in operations when the roots are exposed.

The plants will, of course, be set rapidly or slowly according to the number of men available. Two men, one to puddle, carry, and place the seedlings, and the other to plant, can make good headway. The addition of two men or clever boys to the crew, to puddle, carry, and place the seedlings, would increase the speed of planting greatly. The two who are more skillful and careful should set and fill in about the seedlings and tamp the roots, while the other two men or boys attend them with seedlings.

Stock can be rapidly set by placing ten to twenty seedlings at a time along in the trench at the proper distance apart; then quickly throw the earth in on one side, straighten up the plants, and firmly pack the earth about the roots with the foot. It should be borne in mind that very much depends upon the care and thoroughness with which this filling in and firming the earth is done. The fine earth should be well packed about all the roots, but not rammed. When the earth is carelessly and loosely thrown in about the roots and only lightly tamped, the trees are likely to die outright for lack of close contact with the soil.

Plants should be firmly set in the ground also to enable them to withstand as much as possible the loosening effect of winds, which, in exposed places, are likely to sway the stems and loosen the roots considerably. This may happen even to carefully set plants, especially in light loamy or mucky soils during heavy rains accompanied or followed by high winds. The nursery should, therefore, be looked over after such storms, and the loosened or partly washed-out seedlings should be straightened up, and the earth tightened about their roots.

CARE OF NURSERY STOCK.

CULTIVATION.

Following the transplanting of seedlings to nursery rows the care of this stock will be essentially the same as that described for plants in the seed bed. The nursery should be kept clear of weeds and the surface of the soil stirred frequently with hoe or cultivator, to prevent the evaporation of soil moisture. It is especially necessary that the nursery should be gone over after a rain with hoe or cultivator as soon as the surface soil is dried out sufficiently to work well. This will at once prevent the deeper moisture from drying out about the roots of the trees.

WATERING.

In case no rain falls within two weeks after the nursery plants have been set, the earth at the depth of the tree roots should be examined, and if found to be drying out or likely to do so in a short time, water should be applied to the rows. The method of watering described for seed beds will apply equally well to nursery rows. The earth should be thoroughly saturated at each watering down to the full depth of the roots. The maintenance of a moderately even supply of moisture in the soil should never be overlooked, for the success of the trees depends almost entirely upon proper moisture.

WINTERING.

Before leaving nursery stock for the first winter the rows should be hilled up on both sides. This can be done quickly by throwing one or two furrows against each side of the trees with a small corn plow and finishing with a hoe. In regions where the winters are only moderately cold this hilling up will give quite sufficient protection, while in mild regions of the Middle and Southern States no hilling will be necessary. But where the winters are severe a heavy mulching of green stable manure, leaves, or straw should be added to the hilling between the rows, covering the stems for at least a foot above the earth. Conifers may be mulched well up to the top. When straw or leaves are used for mulching a few rails, poles, or boards should be laid along each side of the nursery rows to prevent winds from blowing the mulch off.

As soon as growth begins in the spring the mulch should be taken off and the banking of earth hoed away from the rows.

HOW LONG STOCK SHOULD REMAIN IN THE NURSERY.

The object of continuing the cultivation of seedlings in the nursery is to make them vigorous and to bring them to a convenient size to insure successful transplanting in the forest plantation. This being accomplished, further nursery training is unnecessary. Sizes convenient for transplanting are from 12 to 18 inches in height.

For most conifers which have grown two years in the seed bed, one year in the nursery row will suffice before final planting; one-year-old seed-bed plants can with advantage be continued in the nursery for two years. The majority of broadleaf seedlings will be fitted for permanent planting with one year in the seed bed and one year in the nursery; further training of rapid-growing, broadleaf species in the nursery is likely to produce plants too large for convenient handling, while the essential vigor of these trees is not materially improved.

USE OF WILD SEEDLINGS.

Use wild seedlings whenever available; they are cheaper to collect or buy than plants raised from seeds. Strengthen wild seedlings by cultivating them in the nursery for one or two years.

The tree planter will usually find it profitable to use wild seedlings whenever possible. It will be considerably cheaper to buy or collect such seedlings than to raise them from the seed, and the additional cost or care in the nursery to fit wild stock for use will be comparatively small.

In general, wild seedlings are not as strong for planting as those of the same age grown in the nursery. This is chiefly for the reason that the wild stock has been established under conditions very different from those in the open, to which it is suddenly transplanted. Not infrequently some kinds of wild seedlings fail completely when transplanted directly from the woods to the open ground, or make very slow progress for a year or two until accustomed to the new situation. But the complete failure of wild seedlings to grow when transplanted from the woods applies mainly to carelessly pulled or otherwise badly handled seedlings. Success with wild seedlings of any age depends largely on the care with which they are taken up and planted. Generally speaking, forest seedlings from one to two or even three years old can be transplanted to the nursery with little loss, provided they are properly taken up, protected in transit to the nursery, and carefully set. Carefully lifted with a spade or otherwise correctly handled 80 per cent of wild conifer seedlings have been made to live. Broadleaf seedlings generally give a higher percentage.

Transplanted wild conifer seedlings need to be shaded during the first season.

SUPPLY OF WILD SEEDLINGS.

Wild seedlings are most abundant in wooded regions, near scattered seed trees where the conditions are favorable for seedlings to spring up. Few seedlings will be found under trees in pastures and dry fields. Wherever trees shed their seed in shaded moist soils there is the greatest likelihood of finding a supply of seedlings. The seedlings of the Pines, Spruces, Firs, Cedars, Junipers, Beech, Cherries, Catalpas, Tulip-tree, Maples, Ashes, Boxelder, Elms, Birches, and Aspens are most common where seed trees grow along water courses or in other moist situations.

Thousands of Willow, Cottonwood, and Boxelder seedlings can be found on the moist sandbars and edges of western streams.

TIME FOR COLLECTING WILD SEEDLINGS.

Wild seedlings may be taken up either in the spring or in the fall. If collected in the fall, broadleaf kinds should be taken up as soon as the leaves are shed, and conifers as soon as the winter buds are fully formed. According to the region, this will be from the middle of October to November; but all seedlings should be snugly packed in trenches ("heeled in") and covered with straw before the ground is frozen.

Spring collecting should be done as early as the frost leaves the ground, and before the buds begin to open.

The instructions given for taking up, handling, and transplanting seed-bed plants should be observed also in collecting wild seedlings.

HEELING IN.

Fall-collected wild seedlings are best temporarily placed in the ground for protection during the winter. In the spring they should be set out in nursery rows. Spring-collected trees may also need similar storing for a few days or weeks, till preparations can be made to plant them in the nursery. This temporary storing is called "heeling in," and consists in planting dense slanting rows of seedlings in a trench. The trees are covered with earth well up above the collar.

To insure the roots being perfectly moist when heeled in they should be first puddled in the manner described for transplanting seed-bed stock. To facilitate this work, a half barrel or large tub, instead of a bucket, may be filled with puddle and placed near the spot where the plants are to be heeled in, or a hole scooped out in the ground near by will serve perfectly well.

The puddle being prepared, and the plants near at hand, a trench is opened by sinking a spade deep into the ground at an angle of about 45 degrees, and throwing the earth out. A dense line of puddled trees is then laid against the slanting side of the trench and 6 inches of earth is thrown over the roots by spading along in front of the trench; this earth is firmly packed about the roots by foot pressure. Another line of plants is laid in the trench just opened by the spading in front, the stems being placed at about the same angle as in the first row. A 6-inch layer of earth is packed against the roots of the second row in the same manner as for the first, and the heeling in is thus continued till all the plants are taken care of. A foot or more of earth should be thrown up against the last row of plants to prevent any exposure of the roots by washing.

In transplanting heeled-in stock in the spring, the roots should be puddled.

LIST OF USEFUL TIMBER TREES TO PLANT.

The following list of trees includes such species as will be useful to the planter. It contains a short description of the habitat of each species. Notes on the appearance of the mature fruits and seeds are given for each species, and statements of the time to collect each kind of seed, the storage best suited to keeping it, and the time to sow it.

Geographical range of species, character of the seed, time to collect, and proper storage for seed of each species.

Name of species.	Where found.	Appearance and character of—		Time to—		Kind of storage.
		Fruit.	Seed.	Collect.	Sow.	
White Pine (*Pinus strobus*)	Eastern United States.	Long, smooth, light-colored, narrow, fragile, early-falling cone.	Small, mottled, with detachable papery wing.	Last weeks of August and September.	Spring........	Dry and cold.
Bull Pine (*Pinus ponderosa*).	Rocky Mountains and westward.	Large, heavy, oval, prickly, strong, more or less persistent cone.	Medium large, mottled, with detachable papery wing.	September and October.	.....do........	Do.
Shortleaf Pine (*Pinus echinata*).	South Central and Southern States.	Small, oval, light-colored, persistent, prickly cone.	Medium large, black-brown, with detachable papery wing.	.....do...........	.....do........	Do.
Loblolly Pine (*Pinus taeda*)	Southern States	Medium, long, cylindrical, clay-brown, more or less persistent, prickly cone.	Medium large, black-yellow, mottled, with detachable papery wing.	.....do...........	.....do........	Do.
Pitch Pine (*Pinus rigida*) .	Mainly Northeastern States.	Medium, broad, conical, light russet-brown, very persistent, prickly cone.	Small, black, with detachable papery wing.	October and November.	.....do........	Do.
Scrub Pine (*Pinus virginiana*).	Mainly Middle Atlantic States.	Small, oval, hard, very persistent, prickly cone.	.....do....................	.....do...........	.....do........	Do.
Lodgepole Pine (*Pinus murrayana*),	Rocky Mountains and westward.	.....do....................	.....do....................	.....do...........	.....do........	Do.
Banksian Pine (*Pinus divaricata*).	Northeastern United States.	Small, close, hard, very persistent, smooth cone.	Small, blackish, with detachable papery wing.	.....do...........	.....do........	Do.
Longleaf Pine (*Pinus palustris*).	Southern States.....	Large, hard, tardily falling, prickly cone.	Large, clay-colored, with large papery wing.	.....do...........	.....do........	Do.
Monterey Pine (*Pinus radiata*).	Southern California	Large, hard, thick-scaled, persistent smooth cone.	Small, black, with detachable with papery wing.	.....do...........	.....do........	Do.
Tamarack (*Larix laricina*).	Northeastern States	Very small, fragile, persistent, smooth cone.	Minute, brownish, with papery wing.	September........	.....do........	Do.
Black and Red Spruce (*Piceamariana and Picea rubens*).	Mainly Northeastern States.	Small, firm (russet-brown), tardily falling, smooth cone.	Minute, brown, with detachable papery wing.	September and October.	.....do........	Do.
White Spruce (*Picea canadensis*).	Northern States	Small, fragile (light-brown), tardily falling, smooth cone.	.....do....................	.....do...........	.....do........	Do.
Blue Spruce (*Picea parryana*).	Rocky Mountain region.	Large, long, narrow, wrinkled-scaled (yellowish), smooth cone.	.....do....................	.....do...........	.....do........	Do.
Engelmann Spruce (*Picea engelmanni*).	.....do..............	Small, short, wrinkled-scaled (red-brown), smooth cone.	.....do....................	.....do...........	.....do........	Do.
Hemlock (*Tsuga canadensis*).	Northeastern States	Very small, fragile, tardily falling, smooth cone.	.....do....................	.....do...........	.....do........	Do.
Red Fir (*Pseudotsuga taxifolia*).	Rocky Mountains and westward.	Small, fragile, bracted, early-falling, smooth cone.	Very small, mottled, with detachable papery wing.	.....do...........	.....do........	Do.
Balsam Fir (*Abies balsamea*)	Northeastern States	Long, narrow, cylindrical, separable-scaled, smooth, upright cone.	Very small, angular, with detachable papery wing; resinous.	.....do...........	.....do........	Do.
White Fir (*Abies concolor*)..	Rocky Mountains and westward.	Medium-large, broad-cylindrical, separable-scaled, smooth, upright cone.	.....do....................	.....do...........	.....do........	Do.
Bald Cypress (*Taxodium distichum*).	Southern States.....	Small, spherical, separable "ball".	Irregular, sharp-angular, woody; resinous.	.....do...........	.....do........	Do.

Incense Cedar (*Libocedrus decurrens*).	Northwestern mountain and coast region.	Very small, narrow, fragile, few-scaled, deciduous, smooth cone.	Small, resinous, with tawny papery wing; fragrant.	.....do	.....do	Do.
Aborvitæ (*Thuja occidentalis*).	Northeastern States	.....do	Minute, with circular papery wing; with strongly balsamic odor.	.....do	.....do	Do.
Pacific Arborvitæ (*Thuja plicata*).	Northwestern coast region.	.....do	.....do	.....do	.....do	Do.
Lawson Cypress (*Chamæcyparis lawsoniana*).	.....do	Very small, spherical "ball"	Minute, with circular, papery wing.	.....do	.....do	Do.
Yellow Cedar (*Chamæcyparis nootkatensis*).	.....do	Very small, spherical, deciduous "ball" (foliage coarser).	.....do	September	Spring	Do.
Red Juniper (*Juniperus virginiana*).	Mainly northeastern States.	Very small, glaucous, resinous, tardily deciduous berry.	Minute, smooth, bony, pointed	September and November.	Spring or fall.	Bury in sand or earth.
Butternut (*Juglans cinerea*)	Eastern States	Large, deciduous, pointed, viscid-glandular, thin-husked nut.	Bony, jagged-rough, thick-shelled nut.	September and October.	.....do	Do.
Western Walnut (*Juglans rupestris*).	Southwestern States	Medium-large, spherical, thin-husked nut.	Bony, smooth, thin-shelled nut	.....do	.....do	Do.
Black Walnut (*Juglans nigra*).	Eastern States	Large, spherical, thick-husked nut.	Bony, rough, thick-shelled nut	.....do	.....do	Do.
Bitternut Hickory (*Hicoria minima*).	.....do	Medium-large nut, with thin and tardily separable husk.	Smooth, thin-shelled, bitter-fleshed nut.	.....do	.....do	Do.
Shagbark Hickory (*Hicoria ovata*).	.....do	Medium-large nut, with thick, deeply divided separable husk.	Thinnish, firm, 4-angled, compressed nut.	.....do	.....do	Do.
Shellbark Hickory (*Hicoria laciniosa*).	Central Eastern States.	Large nut, with very thick, deeply divided, separable husk.	Thick, strong, 4-angled, compressed nut.	.....do	.....do	Do.
Mockernut Hickory (*Hicoria alba*).	Eastern States	Large nut, with half-divided, tardily separable husk.	Thick, very strong, 4-angled nut.	.....do	.....do	Do.
Pignut Hickory (*Hicoria glabra*).	.....do	Medium-large nut, with half-divided, tardily separable husk.	Thinnish, firm, smooth, compressed, oblique nut.	.....do	.....do	Do.
Black Willow (*Salix nigra*).	.....do	Long, narrow cluster of very small, soft, berry-like pods.	Minute, with cotton appendage	July	Sow pods at once.	
Aspen (*Populus tremuloides*)	.....do	.....do	.....do	.....do	.....do	
Large-tooth Aspen (*Populus grandidentata*).	Northeastern States.	.....do	.....do	.....do	.....do	
Cottonwood (*Populus deltoides*).	Eastern States	.....do	.....do	.....do	.....do	
River Birch (*Betula nigra*).	.....do	Small, cylindrical, separable-scaled cone.	Minute, circular-winged	May and June	.....do	
Yellow Birch (*Betula lutea*).	.....do	Small, oval, separable-scaled cone.	.....do	September and October.	Spring or fall.	Dry and cold.
Sweet Birch (*Betula lenta*).	.....do	Small, oval, deciduous-scaled cone.	.....do	.....do	.....do	Do.
Beech (*Fagus atropunicea*).	.....do	Small, soft-prickly, tardily falling capsule.	Small, smooth, thin-shelled, triangular nut.	October and November.	.....do	Bury in sand.
Chestnut (*Castanea dentata*)	Mainly Atlantic States.	Very large, prickly, valvular, deciduous (capsule) bur.	Small, thin-shelled, flask-shaped nut.	.....do	.....do	Do.
White Oak (*Quercus alba*).	Eastern States	Small, deciduous, shallow-cupped acorn.	Small, smooth, oval nut	September and October.	.....do	Do.
Bur Oak (*Quercus macrocarpa*).	East of the Rocky Mountains.	Very large (or medium), mossy, deep-cupped acorn (nut tardily separable).	Large, smooth, oval nut	.....do	.....do	Do.

Geographical range of species, character of the seed, time to collect, and proper storage for seed of each species—Continued.

Name of species.	Where found.	Appearance and character of—		Time to—		Kind of storage.
		Fruit.	Seed.	Collect.	Sow.	
Overcup Oak (*Quercus lyrata*).	Southeastern States.	Medium large, very deep-cupped acorn; nut inseparable.	Large, smooth, oval nut	September and October.	Spring or fall.	Bury in sand.
Chestnut Oak (*Quercus prinus*).	Atlantic States	Large, shallow-cupped acorn	Large, smooth, long-oval nut	do	do	Do.
Chinquapin Oak (*Quercus acuminata*),	Eastern States	Small, shallow-cupped acorn	Small, smooth, oval nut	do	do	Do.
Swamp White Oak (*Quercus platanoides*).	do	Small, shallow-cupped acorn on long stems.	do	do	do	Do.
Cow Oak (*Quercus michauxii*).	Southeastern States	Large, deep-cupped acorn	Large, smooth, oval nut	do	do	Do.
Red Oak (*Quercus rubra*)	Eastern States	Large, very shallow-cupped acorn.	do	do	do	Do.
Yellow Oak (*Quercus velutina*).	do	Small, deep-cupped acorn	Small, smooth, striped nut	do	do	Do.
Spanish Oak (*Quercus digitata*).	Southeastern States	Very small, shallow-cupped acorn.	Very small nut	do	do	Do.
Black Jack (*Quercus marilandica*).	Eastern States	Small, deep-cupped acorn	do	do	do	Do.
Laurel Oak (*Quercus laurifolia*).	Southeastern States	Small, shallow-cupped acorn	do	do	do	Do.
Cedar Elm (*Ulmus crassifolia*).	Southwestern States	Small, thin, winged disk	Not separable from wing	September	Fall	
Slippery Elm (*Ulmus pubescens*).	Eastern States	do	do	May and June	Sow at once	
White Elm (*Ulmus americana*).	do	do	do	do	do	
Cork Elm (*Ulmus racemosa*).	Northeastern States	do	do	do	do	
Winged Elm (*Ulmus alata*).	Southeastern States	do	do	April and May	do	
Hackberry (*Celtis occidentalis*).	Eastern States	Small, dry, sweetish, thin-fleshed berry.	Not separable from pulp	October	Spring or fall.	Bury in sand.
Sugarberry (*Celtis mississippiensis*).	Southeastern States	do	do	September and October.	do	Do.
Red Mulberry (*Morus rubra*).	Northeastern States	Resembling a blackberry (longer).	Minute, smooth, hard	July and August.	Spring	Dry and cold.
White Mulberry (*Morus alba*).	Naturalized (from China).	do	do	do	do	Do.
Russian Mulberry (*Morus alba tartarica*).	do	do	do	do	do	Do.
Osage Orange (*Toxylon pomiferum*).	South Central States, but widely introduced.	Large, orange-like, seed embedded in milky pulp.	Resembles cucumber seed	September and October.	do	Dry and cold or mixed with sand.
Tulip-tree (*Liriodendron tulipifera*).	Eastern States	Small cone with overlapping, separable scales.	Curved, with lance-like wing	October	Spring or fall.	Bury in sand.

Sweet Gum (*Liquidambar styraciflua*).	....do	Small, hooked, long-stemmed ball ("gum ball") (size of hickory nut).	Very small, with detachable papery wing.	September and October.	....do	Do.
Sycamore (*Platanus occidentalis*).	....do	Small, rough, long-stemmed ball, formed of seed (size of hickory nut).	Very small, awl-like, bristly	October and November.	....do	Do.
Service-tree (*Amelanchier canadensis*).	....do	Very small cluster of berries (size of currants).	Minute, smooth		....do	Dry and cold.
Canada Plum (*Prunus nigra*).	Northeastern States	Small, oval, orange-red plum	Flat, bony	August	....do	Bury in sand.
Wild Plum (*Prunus americana*).	Central and Southeastern States.	Small, spherical, orange-red plum	....do	....do	....do	Do.
Black Cherry (*Prunus serotina*).	Eastern States	Long cluster of very small thin, bitter-fleshed cherries.	Small, smooth, spherical, bony shell (¼ inch diameter).	....do	....do	Dry and cold best. Bury in sand.
Huisache (*Acacia farnesiana*).	Southwestern States	Thick, stout, cylindrical, red-brown, wavy pod (pea-like); hard to open.	Smooth, light-brown, bony (¼ inch diameter).	July and August	....do	Bury in sand.
Honey Locust (*Gleditsia triacanthos*).	Eastern States	Long, ribbon-like, twisted pod (hard pulp, sweet).	....do	October	....do	Do.
Kentucky Coffeetree (*Gymnocladus dioicus*).	Central and Northeastern States.	Very thick, broad, large, pod; hard to open (jelly-like pulp, poisonous).	Smooth, circular, bony (size of Chestnut).	October and November.	....do	Do.
Locust (*Robinia pseudacacia*).	Eastern States	Small, thin, easily opened pod	Smooth, bony (⅛ inch)	October	....do	Do.
Sugar Maple (*Acer saccharum*).	....do	In short clusters, medium, 2-winged (samaras).	Wings of equal size	....do	Spring or fall.	Do.
Silver Maple (*Acer saccharinum*).	....do	In short clusters, large, 2-winged (samaras).	One wing small and the other very large.	May and June	Sow at once	
Red Maple (*Acer rubrum*)	....do	In short clusters, small, 2-winged (samaras).	Wings of equal size	....do	....do	
Boxelder (*Acer negundo*)	....do	In long clusters, medium, 2-winged (samaras).	....do	October and November.	Spring or fall.	Bury in sand.
White Ash (*Fraxinus americana*).	....do	In dense clusters, 1-winged keys	Bluntly awl-shaped, long wing at end.	October	....do	Do.
Red Ash (*Fraxinus pennsylvanica*).	....do	....do	Sharply awl-shaped, long wing at end.	....do	....do	Do.
Green Ash (*Fraxinus lanceolata*).	....do	....do	....do	....do	....do	Do.
Common Catalpa (*Catalpa catalpa*).	Mainly Southeastern States, but widely cultivated.	Long, brittle, cylindrical pod, (mostly 8–14 inches long).	Light, thin, narrow, 2-lobed, with two fringed wings.	October and November.	....do	Dry and cold.
Hardy Catalpa (*Catalpa speciosa*).	Mainly South Central States.	Long, brittle, cylindrical pod, (mostly 12–20 inches long).	Light, thin, broad, 2-lobed, with two fringed wings.	....do	....do	Do.

O